The Blast Furnace and Steel Plant

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The Editor's Point of View

SCIENTISTS claim that the energy stored in the atoms of one small coin is equivalent to 80,000,000 hp. Should that energy be released it would revolutionize civilization. Such statements are not made haphazard; they are the result of hundreds of years of constant investigation by trained thinkers.

Research unlocks the storehouse of man's achievements and Nature's secrets, it solves the great problems and the little ones. Research gave us knowledge, philosophy, laws, health, and power, and research alone will provide the means and method whereby some future generation will create a social structure wherein equality of opportunity will become fact rather than theory.

When Nature fails, man turns to research. Great power recoveries born among wasted furnace gases now drive mills, and these same low Btu. gases are now deemed vital for by-product coking operations. The imperfect open hearth, itself a radical advance over earlier methods, may lose its identity through the simple influence of controllable draft studies found practical in other fields of observation.

Research in one direction expands its analagous results to unsuspected applications, while every endeavor lends itself to scientific fact alignment and is enriched thereby.

Research stimulates sustained concentrated thought, and such thought results in action; there is no other line of progress.

The function of a publication is to record the products of research. Where that research inclines toward engineering, definite data in support of premises will undoubtedly assist the reader in defining tendencies.

Research applied is the very sap of the tree of knowledge—but the application is for each himself to make, be he educator, lawyer, doctor, manager, engineer or just plain worker.

Let 1923 be YOUR "Research Year."

Past Year One of Unusual Complications

Sustained Strikes, Both in Fuels and Transportation, Add to the Difficulties of High Costs, Low Profit and Labor Shortage—Remarkable Production Increases Recorded.

By B. E. V. LUTY

USUALLY a year in the iron and steel trade can easily be classified by reference to some plainly dominant characteristic, but the year 1922 is not so readily identified. In this case additional perspective may make the vision clearer. We know what preceded 1922, but we do not know what is to follow. The course of affairs in 1923 may make some of the things of 1922 stand out more prominently.

A year ago, our review of 1921 remarked that it went without saying that the year was one of "readjustment." There was a great liquidation in costs. All items entering into steel making had been reduced except freight rates. Despite the fact that freight charges are a very important element in cost, finished steel prices at the end of 1921 stood at 131 (taking 1913 = 100), while the Bureau of Labor's index number showed that commodities in general stood at 150. Steel stood at 19 points better than the field, despite the handicap of freights.

But what shall we say now? Coal and coke prices are much higher at the end of 1922 than they were at the end of 1921, while wages throughout the iron and steel industry have been advanced and stand almost at the war-time level. If 1921 saw a great stride towards normalcy, towards safe, sound and stable conditions under which industry could prosper for a period of years, then 1922 has seen a great step backwards. Or was the post-war desire for sweeping "readjustment" a mistake? Time will have to determine. We cannot tell now.

There are those who think a market reporter should always write cheerfully and should indeed endeavor to "boost" his market. Others prefer that the plain facts be given. They would rather receive information than have pleasurable emotions stimulated. In case of a review there can be no question as to the spirit of treatment. At a time like this one wants to make an appraisal of the bearing the events of the year are likely to have upon the future.

The Coal Strike.

The market events of 1922 were largely dominated by the coal strike beginning April 1. The strike had been thoroughly advertised, so to speak, beforehand. Not only did all men believe that there was going to be a strike or suspension at the union coal mines, but they recognized the fact long in advance. The coal mining scale, reaffirmed for the biennial period beginning April 1, 1920, became entirely out of harmony with conditions in other industries by the developments of 1921 and as the miners were unlikely to consent to a substantial readjustment, if indeed any at all, everyone recognized that there was going to be a strike. Various actions resulted from this belief. Practically all consumers of coal stocked very liberally, not a few beginning in December. Consumers of steel, fearing that production and transportation of steel might be interfered with should the mining suspension last for several months, bought steel freely and took deliveries as rapidly as they were offered.

Production of steel ingots, which had risen to a rate of 23,000,000 tons a year in October and November, 1921, but dropped to a rate under 20,000,000 tons in December, through buyers wishing to have inventories light, rose rapidly and continuously in January, February and March, reaching a rate of 35,000,000 tons a year by April 1. This seemed to be a high rate, relative to actual production of less than 20,000,000 tons in 1921 and a trifle over 40,000,000 tons in the very active year 1920.

It was a common view at that time that on account of the coal strike steel buyers were purchasing beyond their requirements. The idea was not, it must be understood, that buyers felt they must have the steel in hand on April 1, but rather that they should have it before a possible prolongation of the strike might make steel scarce. An unforeseen event occurred. The Connellsville coke field, always strongly non-union, went out. It had been expected that the country would get along, during a strike of the United Mine Workers, by the combination of stocks and the production of the non-union coal fields. Very serious strikes, however, were produced in the Connellsville region, and operators admitted that they had not expected this. A number of blast furnaces were banked or blown out, and apparently the steel industry was crippled, but as a matter of fact more steel was produced in April than in preceding months.

Here was a question which no one could authoritatively answer at the time, and perhaps the question never can be answered correctly. Increase in the production of steel had been unnaturally restricted. Would there have been greater production had there been no coal strike? The industry would have been free to produce more, but perhaps without the incentive to buying which the coal strike furnished the orders for the steel would not have been in hand.

Steel production increased from April 1 until late in June, in which month the rate of ingot output was approximately 36,600,000 tons a year. The strikes in the Connellsville region caused heavy orders for steam and by-product coal to be placed with non-union mines in West Virginia and Kentucky and in the last fortnight of June the Ohio river crossings became clogged. Then came the railroad shopmen's strike, increasing the difficulty. Coal and coke became scarcer and scarcer and by the end of August, when the union coal strike had just been settled, the production of ingots was down to about 25,000,000 tons a year. The non-union strikes in the Connellsville region, which had been expected to play out long before the union strike should be settled, had continued, and although, after the union settlement by the "Cleveland agreement" the Connellsville operators advanced wages by between 40 and 50 per cent, restoring the record high scale, that of September 1, 1920, the

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strikes persisted. Men gradually drifted back to work until in a short time coke production rose to the transportation limit, while later, with increasing car supplies, it rose to the limit of demand, partly by the importation of new men, yet the United Mine Workers kept the strike nominally alive, resulting late in the year in a full complement of workers, yet many "strikers." One of the few definite facts that may be assembled for an effort to guess whether or not there will be another coal strike next April is this activity of the United Mine Workers in the Connellsville region.

Production of steel decreased in July and slumped in August, fully recovering in September. The average rate of ingot production April 1 to October 1 was about 34,500,000 tons a year. In each of the three months, October, November and December, the rate was approximately 40,000,000 tons a year.

The approach of the coal strike seemed to stimulate steel demand, yet steel production during the strike was fairly large, and afterwards it was larger still. One cannot avoid suspicion that while the year 1922 opened with abnormally small stocks of steel and of manufactures of steel, through the drastic liquidation of 1921, it entered with the country quite well supplied. Steel buyers accepted deliveries in the late months of the year with great equanimity and in many cases with enthusiasm, not even wishing shipments to be curtailed in December, as they often do on account of the annual inventory.

The Course of Prices.

Generally speaking, finished steel prices did all their declining in 1921. Sheets reached their low point, 2.75c, late in August, and soon recovered to 3.00c, while pipe reached its low point, at 71 per cent basing discount, in the middle of December. Bars, shapes, plates and wire products, however, experienced further declines in the first two months of 1922, the heavy rolled products selling down to 1.35c, even lower in some cases, while nails for a little while went at $2.25.

Early in March a general advance in prices began to occur, chiefly under the stimulus of moderately well filled order books. At 1.35c bars, shapes and plates had been altogether too low and it is doubtful whether even a full operation would have afforded mills any margin of profit at this figure. The other products would, in the main, have afforded a moderate profit with a full operation.

In April, May and June steel prices stiffened partly under the influence of demand and partly under the influence of the extra production cost imposed by non-union coal being bought at advanced f.o.b. mine prices and subject to quite unusual freight charges on account of the long hauls involved. By September 1 the coal strike had been settled, but coal, coke and steel were scarce and the cost of making coke was greatly increased. Basis prices of steel, for delivery at mill convenience, were advancing, while in the majority of lines substantial premiums were being paid for early deliveries. In the course of a month or two the premiums disappeared and the market was left steady at uniform prices irrespective of delivery. From the previous low points, reached late in 1921 or early in 1922, advances were as follows: Bars, shapes and plates, 1.35c to 2.00c; nails, $2.25 to $2.70; merchant steel pipe, 71 per cent to 66 per cent basing discount; black sheets, 2.75c to 3.35c. Tin plate was nominally unchanged at $4.75, but was frequently cut to $4.50 or less until about the middle of 1922. Using a weighted average devised by the writer many years ago, and assigning bars a weight of 2½, shapes, plates, pipe, and wire a weight of 1½, sheets a weight of 1 and tin plate a weight of ½, a composite of finished steel made up of the low points would be at 2.01c, while at the open market prices ruling in the closing weeks of the year the composite would be 2.57c, showing a total average advance of $11 a net ton.

In the 10-year period, 1904 to 1913, inclusive, this composite averaged 1.80c, while its lowest point since 1898 was 1.42c, in December, 1914. Under government prices during the war it stood at 3.80c, while the Industrial Board prices of March 21, 1919, made 3.25c.

Production and Demand.

Production of steel ingots in gross tons as officially reported, except that the 1922 figure is an estimate, has been as follows:

1909......	23,298,779	1916......	41,401,917
1910......	25,154,087	1917......	43,619,200
1911......	23,029,479	1918......	43,051,022
1912......	30,284,682	1919......	33,694,795
1913......	30,280,130	1920......	40,881,392
1914......	22,819,784	1921......	19,184,084
1915......	31,284,212	1922......	33,500,000

From the viewpoint of the rapid rate at which steel production and consumption increased before the war the showing of the past two years is a very unfavorable one. It would have been no trick, circumstances being favorable, for 1922 to have shown production at capacity, which is probably about half way between 50,000,000 and 55,000,000 tons. It is not reasonable to extrapolate from a short range basis, and the particular circumstances must be considered. The general supplanting of wrought iron by mild steel occurred in the neighborhood of 30 years ago, and for a long range comparison pig iron has to be taken. Until a few years before the war pig iron production showed a remarkable facility for doubling every 10 years, but it was obvious that a geometrical increase could not continue indefinitely. The rule showed signs of breaking down. The war demand helped matters, but merely confused the statistical record. Population has lately been increasing less rapidly. Steel is a construction material, and construction costs have mounted particularly. Steel is not consumed so much as it is put into employment and the store of steel in service is now very large. A new industry naturally grows rapidly, but steel cannot always be a new industry.

The growth of steel consumption per capita has occurred chiefly through two influences:

(1) The supplanting by iron and steel of other materials.

(2) Improvements whereby a given amount of labor will produce, or fabricate, or put into employment more steel.

Railroad cars are now made of steel instead of wood and the consumption in this field during the past year was good. Opposed to this influence is the fact that the automobile production record was remarkably high in number of cars produced, but the steel consumed was less as the average weight of automobiles is decreasing.

These may seem to be more or less indiscriminate observations, and they are set down largely to supply food for thought to those who have considered the "rule of doubling" natural and inevitable. More logically, one may consider that the growth of steel consumption per capital has occurred chiefly through two influences: (1) The supplanting by iron and steel of other materials; (2) improvements whereby a given amount of labor will produce more steel or fabricate or put into employment more steel. The influence of the first will still be seen. Wooden freight and passenger cars are almost completely replaced by steel cars, and wooden wagons, buggies and carriages by motor trucks and automobiles. Steel is largely supplanting wood in office furniture. Some time it will be much more largely employed in dwelling house construction. As to the second point, there was for a time very rapid improvement in methods of building skyscrapers and bridges, but advancement now is slower.

The country really did fairly well to produce, and presumably very largely to consume, 10 per cent more steel in 1922 than was produced in 1912 and 1913, the two greatest tonnage years before the war. Exports were smaller in 1922 than in those years, whereby the domestic trade showed more than a 10 per cent increase. It is not to the point to measure steel activity by percentage reference to the productive capacity. Before the war productive capacity grew in relation to the normal demand, but the war brought a special demand. There was a very decided labor shortage in the steel industry in the late months of 1922, even though a 20 per cent wage advance was made September 1, bringing the common labor rate to 36 cents an hour, against 46 cents as the high point reached during the war, and rates of about 19 cents in 1913 and 13 cents in 1898. When there is a labor shortage it means that the country is fully engaged. To spirit into the country enough workmen to increase the iron and steel producing industry's working force by 25 per cent or 50 per cent would not permit the production to be correspondingly increased, for the labor to consume the steel would not be furnished. It is merely an incident that the steel ingot productive capacity is thus and so, and the percentage of operation at one time or another well under 100 per cent, when before the war the steel industry was usualy in the dumps and market prices unprofitable when the operation was under 80 or 85 per cent. The proper measure is tons.

While the tonnage of steel made in 1922 cannot be considered poor, there was by no means a uniform distribution of demand all around. The various consuming lines were by no means at their limit. The lines of best demand were in freight cars, passenger cars and locomotives, and in garage and dwelling house construction. There was practically no new construction of railroad line, and little by way of railroad bridges and terminals. The automobile trade gave a remarkably good account of itself, probably with a record production in number of passenger cars and trucks, but not with a new record in weight of automobiles produced or in steel consumed. Statistics are given merely of numbers, but the average weight of automobiles has been decreasing.

In building, there was little construction of hotel and office skyscrapers, but a very remarkable boom in garage and dwelling house construction. While these smaller structures do not require as much steel per dollar spent as do the large buildings, the effect upon the pipe and nail trades was remarkable. The agricultural implement factories had a very poor year, and consumption of steel in the manufacture of machinery of various descriptions was considerably less than should be expected when the country gets down to serious and hard work after the mental dislocations produced by the war.

Developments in Metallurgy of Iron and Steel

A Brief Report of Some of the Important Achievements Recorded in Current Periodicals and Presented as Papers Before National Societies During the Past Year.

By S. L. GOODALE* and KENNETH D. DODD†

A GREAT deal of development work is in progress in almost every possible branch of metallurgical work in iron and steel, and, in fact, other metals as well. The post war activity in research that was expected has developed into a reality. The results of much of this work are not reported at all promptly for various reasons, and the present review will merely present some of the developments that have been brought to the writer's attention and which seem to be worth emphasizing at this time.

From the standpoint of large scale production much effort has been put forth in the effort to secure better fuel economy in various furnace operations and a more economical handling of materials, these efforts having been forced by the high cost of fuel and labor respectively. As is also to be expected, because of the demand for high quality and dependability in steel products in large tonnage lots, a great deal is being done in tonnage quality production. Neither of these lines of effort is new, but attention has been increasingly drawn to them in recent months.

Important Investigations in Blast Furnace Operation.

In blast furnace study one of the most interesting and important investigations going on is that which is being done by the United States Bureau of Mines at Minneapolis, Minn. To supplement the plant investigations which the blast furnace research section of the Bureau is conducting, a small experimental blast furnace was erected, and a number of combinations of furnace lines and operating conditions have been tried out. A labora-

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tory study of reduction of iron oxides by carbon monoxide in the presence of some 65 per cent of nitrogen is also on the program. It is felt that the plant studies can never solve some of the important questions because of the large amounts of material being handled in actual operation and the many variables. A small furnace is needed in which conditions can be varied to suit research requirements. Later, new things worked out on the small scale can be tried in the regular furnaces of commercial size.

Considerable interest in oxygen enriched air for use to burn fuel in metallurgical furnaces, such as the blast furnace, the open hearth, and others, has been aroused during the year again. Pure oxygen would not be necessary or desirable in the blast furnace—air enriched up to perhaps 25 per cent to 35 per cent by volume of oxygen, more or less, is what is desired, and to be of commercial use the oxygen enrichment must be done at a very low cost indeed. In this way extremely high temperatures would be available together with a suitable volume of hot gas to preheat the charge in the upper part of the furnace, the proper balance between these factors will have to be worked out if the cheap oxygen is made available. While the method has been tried experimentally in former years, the limitation due to the cost of the oxygen has prevented its general adoption, or even any thorough study of the plan under varied circumstances. The United States Bureau of Mines has a committee studying the matter of a cheap source of oxygen.

Open Hearth Developments Are Promising.

In the development of the open hearth furnace an important step was taken in the formation of the open hearth combustion system, by the combination of the interests controlling the McKune and the Egler types, and some other similar ones. In this way operators will be enabled to try out the advantages of these improvements without the fear of being involved in patent legislation. Where these furnaces have been installed and where conditions have been such as to give them a fair trial, the fuel used has been decreased some 10 per cent and the production increased about 20 per cent. It is believed that further improvements will be secured as the types are better developed.

Briefly, the principle applied is that of the blow torch, by which the combustion of the gas in the first half of the hearth is secured. This is largely the result of better mixing of gas and air, and yields a notably higher temperature over the hearth, with better absorption of the heat into the bath so as to cool down the waste gases more thoroughly before they leave the hearth. It is necessary to have the velocity of the gas and air high enough to prevent preignition taking place in the ports by which an excessive temperature would be produced and the ports destroyed quickly. A paper by Willis McKee in July in the *Iron Age* described this as used at the plant of the Briar Hill Steel Company. Some 10 years ago a test over some weeks run at Homestead showed that in the open hearth the heat actually utilized in making steel amounted to only less than 5 per cent of the calorific power of the fuel used, which shows how greatly the recent developments were needed.

Several excellent studies on heat balances of the open hearth furnace have been published during the year, and also other papers on furnace design in general, and on fuel economy in heating furnaces, etc. In fact, the subject seems to be receiving real attention as it needs. One of the most promising directions from which help may be expected in securing high fuel economy is in the installation of waste heat boilers. Use can be made of at least a commercially large percentage of the large amount of heat now going up the stack. Ordinary good boiler practice will abstract much heat from the stack gas that leaves the regenerators at too low a temperature for use in a steel melting furnace even in its regenerators, but at a high enough temperature to be useful in boiler practice.

One other point should be mentioned in this connection as now receiving something like accurate study and that is refractories. Of course refractories have been vastly improved since the principle of regenerative firing was introduced by Siemens, but it is still true that the lack of better refractories is the thing that holds up much in the way of bettering the open hearth. The limit of temperature that the refractories will stand is the limit of temperature obtainable now in this process. A much higher flame temperature can be obtained if the furnace walls would stand it.

From another standpoint, the paper by Col. Barba and Dr. Henry M. Howe on the manufacture of fine steel in the acid open hearth furnace should be mentioned. This discusses in a very thorough way the questions of temperature and slag composition and other matters in making gun steels especially, and fine steels generally, and is well worth careful study.

The Electric Furnace.

The electric furnace has been gaining rapidly in the tonnage of high quality steels produced. Dr. Mathews outlined in an important paper before the American Iron & Steel Institute in October the present status of the electric furnace. Factors in its increasing importance are the cheaper power available because of improved power house appliances, and also the fact that the process is now better understood than formerly, and more men are available who can operate the furnaces with success. Electric steel is not necessarily of a high grade, but the electric furnace is superior to the open hearth furnace in one respect at least in that it can maintain steel melted under either neutral or reducing slag as desired, whereas in the open hearth furnace practically the reducing slag cannot be maintained at all or only with great difficulty. When full advantage is taken of the possibilities the electric furnace can produce very high quality steel in large tonnages.

An account of improvements and developments in steel mill practices indicating both probable trend of future tendencies as gleaned from a review of the literature of the engineering societies, and from the technical press. Prof. Goodale in this article emphasizes the effect which the demand for large scale production is having on improvements, and intimates that fuel economy will have a more important place in the future than ever before.

In considering fuel economy, mention may be made of the paper read by Mr. W. P. Chandler, Jr., before the American Iron and Steel Institute in October, comparing the efficiencies obtained in heating furnaces of the regenerative and those of the continuous, so-called, recuperative type. His conclusion was that developments will be more likely to be effective along the line of the continuous type.

Centrifugal Casting Is Being Applied Commercially.

The progress in centrifugal casting seems to have been rapid during the past year, and it is now in regular use for many products in cast iron and steel, especially of pipe or ring form. The Hurst melting equipment, in use at a Scotch plant, as described in a paper before the West of Scotland Iron and Steel Institute, consists of a cupola charged from the ground level by means of a bucket belt elevator on an incline. This cupola has an oil fired forehearth into which the metal runs continuously, and also other tap holes which can be used when desired. The forehearth is of considerable advantage, as it permits low carbon and steel mixtures to be produced regularly and the metal to be held a reasonable time in the forehearth, say a couple of hours if necessary, while not consuming over 5 to 8 gallons of oil per hour. Some of the resulting metal has shown very peculiar results in segregation, some of which may be used to advantage in the process.

Work reported in the *Iron Age* in September by L. Cammen produced especially good structures in high carbon chromium steel for ball bearing races. This centrifugally cast steel had a structure as fine as if it had been rolled and heat treated and showed no trace of dendrites. If we could just let steel solidify in about the way we freeze ice cream, what a nice piece of metal would result, all steel—some of the ice cream folks say "all cream"—no dendrites, no gas, no foreign inclusions, no segregation—just steel, with a grain as fine as desired. Most centrifugal casting has been done with the axis of rotation horizontal, but it has been proposed to use a vertical axis also; and N. Lilienberg published an interesting paper last July in this journal showing what forms can be cast to advantage in that way.

Mechanical Puddling.

Mechanical puddling is revived as a commercial possibility by the Titan Iron & Steel Company, Inc., of Newark, and by the Youngstown Steel Company of Youngstown, Ohio. The pig iron is charged molten into the converting furnace, being cheaper to melt in a cupola. The furnace is cylindrical on a horizontal axis, and has a dam running lengthwise and reaching nearly to the center of the furnace. In operation the furnace is rocked back and forth to keep the melted iron pouring back and forth over the bridge in contact with iron ore or other oxides. The furnace is lined with magnesite. A thorough mixing of the metal and oxide is secured, and when finished the ball is removed through a hole in the top then turned down and taken to a squeezer. This squeezer is also of novel design, working on a horizontal axis.

Magnetic and electric testing of butt welded plate. A method of electrically and magnetically testing the quality of a butt weld in plate has been developed by Messrs. Spooner and Kinnard of the Westinghouse Reserch Laboratories which gives promise of being able to be developed to great usefulness in the test of such material without destruction. It may be possible also to extend its use to such work as testing of rail welds in place.

The decarburization of ferrochrome by hydrogen has been accomplished both slowly at temperatures below the melting point of the alloy and very rapidly by bubbling the hydrogen through the melted alloy. It would seem also as if it might be possible to use the hydrocarbon resulting from this reaction for some useful purpose.

Theoretical Developments.

In the study of finished iron and steel there have been a number of interesting developments during the year so that it is a matter of choice which to mention in a brief review. One of the latest pieces of work on the iron carbon diagram indicates a welcome simplification of the diagram in that the double equilibrium is no longer considered to be necessary by the authors. The researches from the standpoint of X-ray spectrogrophic analysis do not seem to have led to any startlingly new results; although in time it is believed that this method will be of the greatest assistance in clearing up many doubtful points in steel metallography.

An interesting set of curves was reported from the Bureau of Standards showing .04 percent C to be the lowest limit of carbon content in iron in which the pearlite transformation point shows on heating and cooling curves. This limit could be taken as the lowest carbon content of metal to be classed as steel.

Messrs. Jordan & Swindells reported in *Chemical and Metallurgical Engineering* some work showing very definitely that nitrogen may exist in steel in at least two different forms, thus explaining some hitherto apparently conflicting evidence in regard to the gas content of steel under certain conditions.

Some interesting results have been obtained during the year in regard to selective case hardening of parts, the parts to be kept soft being protected during case hardening by an electro-plated copper coating on the steel. Copper coating by plain immersion was found not to be reliable for this purpose, but when plated by electrolysis even an extremely thin coating was sufficient to prevent carbonizing.

Electrolytic production of iron is increasing very much in importance. The Western Electric Company is reported to be producing about two tons per day of iron electrolytically from sulphide ores. Since sulphide ores of iron are very plentiful, electrolytic iron produced diectly from such ores may become a very important product. The purity of the product can be about as high as desired by taking proper precautions in the electrolysis. Furthermore by suitable arrangements the iron may be deposited in thin sheets on rotating cylindrical mandrels and by suitable heat treatment be obtained in a shape almost ready for immediate use in the arts. The high purity of these sheets would make them especially valuable for their rust resisting properties and high electical conductivity as well as for their magnetic properties.

The latter part of the year especially has been a period of consolidations and mergers in the iron and steel industry and it is probable that there will be many interesting metallurgical developments coming out of the new business combinations so formed.

In general it may be considered that the present period in metallurgy is one clearly characterized by developments looking toward high quality in the product, and low costs in operation to meet very keen competition.

The Koppers Company has been awarded a contract by the Crucible Steel Company covering the erection of 12,000,000 cu. ft. liquid purification plant at Midland, Pa. This is the first liquid purification plant to be built in connection with a steel mill for the purpose of purifying coke oven gas for use in the open hearth furnaces, and the results will be watched with great interest. It is expected that the plant will be put into operation by the first of March.

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Review of Iron and Steel Literature for 1922

A Classified List of the More Important Books, Serials and Trade Publications During the Year; With a Few of Earlier Date, Not Previously Announced.

By E. H. McCLELLAND

Technology Librarian, Carnegie Library of Pittsburgh

THIS is the sixth annual review of the literature of iron and steel prepared for THE BLAST FURNACE AND STEEL PLANT. The purpose is to list all publications of 1922, together with those of the preceding year not available for inclusion in the previous review. Many foreign publications of 1921 were not listed or reviewed in the technical press until late in 1922.

Where possible, the works listed have been personally examined by the compiler of this review. Certain publications, however, were not available and the only information regarding them was in reviews in technical journals, which in many cases failed to give adequate information. Some of the entries are therefore incomplete, and some are probably inaccurate.

A word should be said about prices—those listed are from book reviews or publishers' lists. Book prices are constantly fluctuating, however, and, at present, no published list can be depended on for prices of foreign books. Prices of German works are, of course, particularly unstable.

This list is confined to separately published works. Much additional literature is available in current periodicals, and comprehensive indexes to this scattered material may be consulted in the Carnegie Library of Pittsburgh.

At present, there is much interest in unstainable, or "stainless," steel. A list of references on this subject appears in *Forging and Heat Treating* for December, 1922.

GENERAL

Geology, Metallurgy, Testing.

Akademischer Verein Huette. "Huette" Taschenbuch fur Eisenhuettenleute. Ed. 2, revised and enlarged. 963 pp. 1922. Wilhelm Ernst, Berlin. 738 marks.

Bagnall-Wild, R. K., and others. Aircraft Steels and Material. 217 pp. 1922. Constable & Co., London. 16 sh.

Bauer, O., and Deiss, E. Probenahme und Analyse von Eisen und Stahl. Ed. 2, revised and enlarged. 304 pp. 1922. Julius Springer, Berlin. 472 marks.

Behaghel, Georg. Die Eisen- und Manganerze Osteuropas. 361 pp. Teubner, Leipsic.

Occurrence, sampling and mining of ores

Canadian Institute of Mining and Metallurgy. Transactions, 1921. v. 24, 338 pp. 1922. The Institute, Montreal.

Includes Transactions of the Mining Society of Nova Scotia, and contains considerable information on coal mining, and ferrous metallurgy.

Carnegie Steel Company. Shape Book. Ed. 8, 373 pp. 1921.

Profiles and data relating to shapes, plates, bars, rails and track accessories.

Carnegie Steel Company. Standard Specifications; Steel for Bridges, Buildings, Locomotives, Cars, and Ships, Boilers and Rivets, Concrete Reinforcement. Wheels and Gear Blanks,, Axles and Shafts. Ed. 9, 156 pp. 1922.

Includes official specifications of Association of American Steel Manufacturers; American Society for Testing Materials; Carnegie Steel Company; American Railroad Association, Section III, Mechanical; and American Bridge Company.

Colvin, Fred H., and Juthe, K. A. The Working of Steel. Ed. 2. 245 pp. 1922. McGraw-Hill Book Co., New York. $3.

Not enlarged, but publishers state that new edition "presents revision of the material on metallography and on the influence of chemical composition upon the properties of alloy steels, and includes new material on methods of physical testing."

Diegel, C. Beschaffenheit des Flusseisens fur gute Schmelzflammen-Schweizung. 44 pp. and 12 plates. 90 marks.

Author is technical director of the "Société Julius Pintsch."

Firth (Thomas) & Sons. Development of Stainless Steel; Its Properties and Uses. 82 pp. Sheffield. 10 s. 6 d.

"A very complete treatise upon the nature and properties of stainless steel, formed by a collection of reports and data from the firm's research laboratories. * * * As this is, so far as we are aware, the only work dealing exclusively with stainless steel, it has a unique value to those interested in the subject."—*Electrical Review* (London), August 4, 1922.

Forsythe, Robert. The Blast Furnace and the Manufacture of Pig Iron. Ed. 3, 371 pp. 1922. U. P. C. Book Co., Inc., New York. $4.

Practically a reprint of 1908 edition.

Foucard, A. Technologie de la forge; les tuyeres. 95 pp. 1921. Dunod, Paris. 8 fr. 6.

Description of numerous types of horizontal, vertical and inclined tuyeres, discussion of choice and position of tuyeres, and special consideration of blast furnace tuyeres.

Friend, J. Newton. Corrosion of Iron. 161 pp. 1922. Iron and Steel Institute, London. 16 sh. (Carnegie Scholarship Memoirs, v. 11.)

Collected papers by the author. A few footnote references.

Fuchs, Otto. Schmiedehammer. 150 pp. 1922. Julius Springer, Berlin. 132 marks.

Deals with construction and operation.

Gentry, George. Hardening and Tempering Engineers' Tools. 61 pp. n.d. Percival Marshall & Co., London. 9 d. net. (Model Engineer Series, No. 43.)

Includes case-hardening and forging of lathe tools.

Geusen, L. Die Eisenkonstruktionen. Ed. 3, 282 pp. 1921. Julius Springer, Berlin. 384 marks.

Geuze, Leon. Traité théorique et pratique du laminage du fer et de l'acier. Ed. 2. 2 vols. 1921. Ch. Beranger, Paris.

Volume 1, text, contains 280 pages; volume 2 consists of 84 plates.

Gillett, H. W., and Mack, E. L. Experimental Production of Alloy Steels. 81 pp. 1922. Government

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Printing Office, Washington, D. C. (United States Bureau of Mines. Bulletin 199.)

Grard, C. L'acier; aviation, automobilisme, constructions mécaniques, sanctions de la guerre. Ed. 2. 364 pp. 1921. Berger-Levrault, Paris. 30 fr.

Guillet, Leon, and Portevin, Albert. An Introduction to the Study of Metallography and Macrography. Translated by Leonard Taverner. 289 pp. 1922. G. Bell & Sons, Ltd., London. £1 10 sh.

In addition to the general information, a chapter of some 70 pages is devoted to iron and steel.

Hadfield, Robert A. The Work and Position of the Metallurgical Chemist. 97 pp. 1922. Charles Griffin & Co., London. 10 sh. 6 d.

Deals to a considerable extent with historical development of chemistry and metallurgy.

Hamilton, Douglas T. Machine Forging; a Treatise on Bolt, Nut and Rivet Forging and the Application of Forging Machines to Forming, Welding and Upsetting Operations on Machine Parts. 106 pp. 1921. Industrial Press, New York.

Harvey, Leonard C. Pulverized Coal Systems in America. Revised et. 117 pp. 1922. H. M. Stationery Office, London. 5 sh. (England—Fuel Research Board. Special Report No. 1.)

Includes application to metallurgical furnaces.

Hearson, H. R. Manufacture of Iron and Steel; a Handbook for Engineering Students, Merchants and Users of Iron and Steel. Ed. 2, 102 pp. 1922. E. & F. N. Spon, London. 5 sh.

Outline describing processes in non-technical language.

Hermanns. Hubert. Das moderne Siemens-Martinstahlwerk. 210 pp. Wilhelm Knapp, Halle a S. $3.

Howe, H. M. La métallographie de l'acier et de la fonte; translated by Octave Hock. 706 pp. 1922. Ch. Béranger, Paris. 120 fr.

Hudson, O. F., and Bengough, G. D. Iron and Steel. 1921. Constable & Co., London. 12 sh. 6 d.

Industrial Application of Ball Hardness Test, with Brinell Hardness Number Tables. Alfred Herbert, Coventry. 3 sh. 6 d.

Iron and Steel Institute. Journal. Vol. 104, 466 pp. 1921. Vol. 105, 712 pp. 1922.

The latter part of each volume abstracts literature in all languages, constituting the best guide to the current literature of ferrous metallurgy. V. 105 has a bibliography of 39 references on hydrogen and decarburization of iron (p. 141) and one of 32 references on crystallization of carbon steels (p. 377).

Kraemer, W. Bandwalzwerke; Weissblech-Weissband. 33 pp. 1922. G. Wilberg, Bochum.

Lagardelle, Gabriel. Manuel du forgeron. 419 pp. 1921. J. B. Baillière, Paris. 10 fr. 80.

Forging tools, methods, and costs.

Ledebur, A. Leitfaden fuer Eisenhuetten-Laboratorien. Ed. 11, revised by H. Kinder and A. Stadeler. 182 pp. 1922. F. Vieweg, Brunswick, Germany. 240 marks, bound.

Loewer, E. Einfuehrung in die Eisenhuettenkunde. 96 pp. 1921. Bonness & Hachfield, Potsdam.

Marcotte, Ed., and Berchare, E. Les Matériaux des constructions mecaniques et aeronautiques. 414 pp. 1921. Dunod, Paris.

Concerned largely with metallurgy, and approximately half the volume deals with manufacture, treatment and properties of iron and steel.

Michel, Jacques. Travail des metaux. 355 pp 1921. Desforges, Paris. 10 fr. 8.

General treatise on metal working, including considerable material on heat treatment of steel.

Mills, A. P. Materials of Construction; Their Manufacture and Properties. Ed. 2, edited by H. W. Hayward. 1922. John Wiley & Sons, Inc., New York.

Not paged consecutively. A total of 162 pages on ferrous metals.

Neale, R. E., comp. Metallurgy of Iron and Steel; Based Mainly on the Work and Papers of Sir Robert A. Hadfield. 122 pp. 1922. Sir Isaac Pitman & Sons, London. 2 sh. 6 d.

Very brief outline.

Oetling, C. Schmiede und Schmiede-Technik; ein Handbuch fuer Betriebsleiter, Schmiedmeister und Studierende. Vol. 1, 608 pp. 1920. R. Oldenbourg, Munich, 1920. 260 marks.

Osann, Bernhard. Lehrbuch der Eisenhuettenkunde. Vol. 2, 794 pp. 1921. W. Engelmann, Leipsic.

Pickands, Mather & Company. Cargo Analyses; Lake Superior Iron Ores for Season 1921. 19 pp. 1922. The Company, Cleveland.

Preger, Ernst. Die Bearbeitung der Metalle in Maschinenfabriken durch Giessen, Schmieden, Schweissen, Harten, und Tempern. 378 pp. 1921. Max Jaenecke, Leipsic. 33 marks.

Preuss, E. Die praktische Nuetzanwendung der Pruefung des Eisens durch Aetzverfahren und mit Hilfe des Mikroskopes. Ed. 2, revised. 124 pp. 1921. Julius Springer, Berlin .

Pulsifer, H. B. Determination of Sulphur in Iron and Steel. 160 pp. 1922. Chemical Publishing Co., Easton, Pa.

Covers the subject fully.

Puppe, J. Etudes sur les laminoirs; translated from the German by P. Denole. 307 pp. 1922. Dunod, Paris. 70 fr.

Pueringer, R. Das Eisen; seine Herkunft und Gewinnung. 74 pp. 1922. Schulbucherverlag, Vienna. 280 kronen.

Rockwell (W. S.) Company. Elements of Industrial Heating. 44 pp. 1922. The Company, New York. Gratis.

Pamphlet, presenting concise data concerning properties of fuel and selection for various purposes, heat distribution and furnace selection. Includes numerous sketches of annealing and heat-treating furnaces.

Rouelle, Jean. L'acier; élaboration et travail. 200 pp. 1922. Armand Colin, Paris.

Rustproofing Processes. 59 pp. 1921. Industrial Press, New York. $1.

Protective paints and zinc coating and chemical processes for prevention of corrosion of iron and steel.

Ryerson (Joseph T.) & Son. Ryerson Steel-Service Book. The Company, Chicago.

Six trade publications in ring binder bearing above title. Includes stock lists, prices and discounts, special products, machinery and tools, data and tables.

St. Paul Foundry Company. Handbook of Tables and Information Appertaining to the Use of Cast Iron, Structural Steel, and of This Company's Products for Engineers, Architects, Builders. Ed. 4, 284 pp. 1922. The Company, St. Paul, Minn. $1.50.

Properties, structural details, and miscellaneous information, with brief catalogue of products.

Tammann, Gustav. Lehrbuch der Metallographie; Chemie und Physik der Metalle und ihrer Legierungen. Ed. 2, revised. 402 pp. 1921. Leopold Voss, Leipsic.

United States Steel Corporation. Manual de Bolsillo sobre Acero para Construcciones. 716 pp. 1922? The Corporation, New York.

Reviewed in "Ingenieria Internacional," Dec.. 1922, p. 355.

United States Steel Corporation—Chemists Committee. Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Coal, Coke and By-Products. Ed. 2, 1848 pp. c1923. Carnegie Steel Co., Bureau of Instruction, Pittsburgh. $3.

Revised extensively. New material includes physical tests, fusibility of ash, and determination of forms of sulphur.

United States Steel Corporation—Chemists' Committee. Methods of the chemists of the United States Steel Corporation for the Sampling and Analysis of Pig Iron. [Ed. 2.] 40 pp. 1922. Carnegie Steel Company, Bureau of Instruction, Pittsburgh. $1.

Supersedes edition of 1912. One of a valuable series of standard "Methods" of steel-works analysis developed or adopted by the corporation.

Verein deutscher Eisenhuettenleute. Gemeinfassliche Darstellung des Eisenhuettenwesens. 605 pp. 1921. Verlag Stahleisen, Duessendorf. 60 marks.

Vita, Albert, and Massenez, C. Chemische Untersuchungsmethoden fur Eisenhuetten and Nebenbetriebe. Ed. 2, revised. 197 pp. 1922. J. Springer, Berlin. 78 marks.

A concise, but thorough, compilation of important analytical methods not only for iron and steel, but for coal, gas, coal tar and its products and the more important non-ferrous metals.

Vulcan Boiler and General Insurance Company, Ltd. Boiler Steel and Experience with High-Pressure Steam Boilers. 102 pp. n. d. The Company, Manchester, England. 2 sh. 6 d.

About half the work is devoted to manufacture, treatment and properties of steel.

Weller, George. Elastizitaet und Festigkeit von Spezialstaehlen bei hohen Temperaturen. 1921. Verein Deutscher Ingenieure, Berlin. 18 marks.

West, Clarence Jay. Reading List on Vitreous Enameling of Iron and Steel. 27 pp. 1921.

Books; magazine articles, 1907-1920; and United States patents.

West Virginia—Geological Survey. Map of West Virginia Showing Coal, Oil, Gas, Iron Ore and Limestone Areas. 1921. The Survey, Morgantown.

Scale, eight miles to the inch.

Accompanied by "List of Coal Mines," in separate pamphlet.

Woods, Keith B. Cost Accounting in the Manufacture of Iron and Steel Sheets. National Association of Cost Accountants, New York.

Pamphlet. Reviewed in "Administration," Dec. 1922, p. 759, but review gives no indication of size, price, or date.

Wormald, Tom. The Blacksmith's Pocket Book. 87 pp. 1921. Scott, Greenwood & Son, London. 6 sh. (Broadway Engineering Handbooks, v. 32.)

Includes reading of drawings, methods of forging, die making, and press work and discussion of various special jobs.

Wuest, Fritz, ed. Mitteilungen aus dem Kaiser-Wilhelm-Institut fur Eisenforschung zu Duesseldorf. v. 2-3, pt. 1. 1921. Verlag Stahleisen, Duesseldorf.

These two volumes contain 10 monographs by various authors. Volume 1 appeared in 1920.

Economics, Statistics, Directories.

American Hardware Jobbers' Directory of the United States and Canada, and Trade Name Index. Ninth annual edition. 262 pp. 1922. E. G. Baltz, Pittsburgh. $2.50.

In seven sections, most of which are arranged geographically. Includes shelf and heavy hardware, New York exporters, department stores, manufacturers' agents, and jobbers of automobile accessories.

American Iron and Steel Institute. Annual Statistical Report for 1921. 96 pp. 1922. The Institute, New York. $3.50.

Statistics of production of iron and steel products, and consumption of raw materials of the industry.

American Rolling Mill Company. The First Twenty Years; a History of the Growth and Development of the American Rolling Mill Company, Middletown, Ohio, Beginning 1901 and Ending 1922. 320 pp. 1922. The Company, Middletown, Ohio. $2.50.

An attractive book, valuable not only for the record of this one company, but as a general contribution to history of ferrous metallurgy.

Bruns, H. Der Eisenwirtschaftsbund. Heft 6. 94 pp. G. Fischer, Jena. 1922. 36 marks.

Burchard, Ernest F. Iron Ore, Pig Iron and Steel in 1919. Published Oct. 14, 1921. Government Printing Office, Washington, D. C.

Advance publication, comprisings pp. 621-652 of the United States Geological Survey's "Mineral Resources of the United States, 1919," Part 1.

Burchard, Ernest F., and Davis, H. W. Iron Ore, Pig Iron and Steel in 1920. Published January 23, 1922. Government Printing Office, Washington, D. C.

Advance publication comprising p. 365-399 of the United States Geological Survey's "Mineral Resources of the United States, 1920," Part 1.

Butler, J. G. Fifty Years of Iron and Steel. Ed. 6. 1922. Privately published.

Campana, C. R., and Turck, R. Metallurgie et siderurgie en Australie. 201 pp. 1922. Office National du Commerce extérieure, Paris. 5 fr.

Cavalier, Camille. Notes economiques d'un metallurgiste. 153 pp. 1921. Gauthier-Villars, Paris. 7 fr.

"These brief economic discussions, by a French iron manufacturer, treat various problems of French industry, particularly metallurgy * * * and the causes of and remedies for the present economic crisis are discussed in the light of long experience in industry."—*Mechanical Engineering,* Dec., 1922.

Comite des Forges de France. Annuaire, 1921-1922. 868-1006 pp. 1922.

Trade directory.

Delany, Mary Cecilia. Historical Geography of the Wealden Iron Industry. 62 pp. 1921. Benn Bros., London. 4 sh. 6 d.

An attempt "to bring out the bearing of the old industry on the life of the district in subsequent generations."

Deutschlands Bergwerke und Huetten; Jahr- und Adressbuch der gesamten Bergwerks- und Hutten-Industrie Deutschlands. 1921/1922. 2 vols. 1921. Spaethe & Linde, Berlin.

Hardware Age Verified List of Retail Hardware Merchants, Hardware Wholesalers, Manufacturers' Agents, 5c, 10c and 25c Stores, Hardware Export Merchants, Sporting Goods Retailers, Department Stores, Woodenware Wholesalers. 1922. Hardware Age, New York. $10.

Jahrbuch Eisen und Stahl. Jahrgang 1921/1922. Ausgabe 1, Schwerindustrie. 420 pp. 1921. Gerhard S. Knop, Essen, Germany.

Directory of the German iron and steel industry, giving considerable information in regard to organization and equipment of the various plants.

Levainville, Jacques. L'industrie du fer en France. 212 pp. 1922. Armand Colin, Paris. 6 fr.

McLeish, John. The Production of Iron and Steel in Canada during the Calendar Year 1919. 45 pp. 1921. Government Printing Office, Ottawa, Canada.

Metal Statistics. Ed. 15. 512 pp. 1922. American Metal Market Co., New York. $1.

Statistical information on both ferrous and non-ferrous metals.

Mineral Industry during 1921. 895 pp. 1922. McGraw-Hill Book Co., New York. $10.

On pages 343-398 Edwin F. Cone reviews the iron and steel industry for 1921.

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Penn Iron & Steel Company. Iron Making, 1814. [5 pp. 1922.] The Company, Creighton, Pa.

Small pamphlet, containing an article on "The first rolling of iron bars in America." Reprinted from "The Cambrian," vol. 5, 1885.

Walker, Charles Rumford. Steel; the Diary of a Furnace Worker. 157 pp. 1922. Atlantic Monthly Press, Boston. $1.75.

By a college graduate who studied labor conditions through actual experience in steel-works.

Electrometallurgy and Other Applications of Electricity.

Allgemeine Elektricitaets-Gesellschaft. Elektrizitaet in Eisenhuettenwerk. Berlin.

An illustrated pamphlet dealing with electricity in the iron and steel industry.

Association of Iron and Steel Electrical Engineers. General Specification of A.C. Motors for Main Roll Drive. 15 pp. n.d.

Very slightly changed from that which appeared with discussion in Proceedings of the Association, 1919, p. 569-599.

"Results of two years' discussion on the subject of Standardization of Rating of Large Rolling Mill Motors."—*Preface.*

Association of Iron and Steel Electrical Engineers. Proceedings. 1921. 705 pp. 1922. The Association, Pittsburgh. $5.

Contains complete chronological and classified lists of papers before the Association since its organization (1907).

Dickmann, Herbert, comp. Bibliographie uber die Darstellung des Roheisens im elektrischen Ofen. 15 pp. 1921. Verlag Stahleisen, Duesseldorf.

Books and magazine articles, 1899-1920.

Gow, C. C. Electro-Metallurgy of Steel. 351 pp. 1921. Constable & Co., Ltd., London. £1 7 sh. 6 d.

History, design, and operation. Includes application in foundry, and consideration of refractories, manufacture of electrodes, and methods of rapid analysis.

Hughes, W. E. Electro-Deposition of Iron. 1922. H. M. Stationery Office. 6 sh. 6 d. (England—Scientific and Industrial Research Department. Bulletin 6.)

Judson, L. C., and Martin, H. P. The Electric Furnace in the Iron Foundry. 1922. American Electrochemical Society.

Bibliography covering the period 1913-1921. A paper before the Society.

McFarlane, William. Electricity in Steel Works. 109 pp. 1921. Sir Isaac Pitman & Sons, Ltd., London. 2 sh. 6 d.

Very brief general treatment. Has a bibliography of only a few references, scarcely touching the literature of the subject.

Foundry Practice.

American Foundrymen's Association. Standard Foundry Cost System; compiled by C. E. Knoeppel & Co., Inc. 65-144 pp. The Association, Chicago. $2.

"This book was originally a part of vol. 28 of the Transactions of the A. F. A., but was later published separately. * * * The system applies both to iron and metal foundries and it is complete in every respect."—*Metal Industry,* Oct., 1921.

American Malleable Castings Association. Certified Malleable in Transportation and Industry. 32 pp. 1922. The Association, Cleveland.

Pamphlet dealing with physical properties and commercial applications of "certified" malleable castings, and outlining the work of the Association in endeavoring to improve quality and promote uniformity of castings.

Boswell, P. G. H. Comparison of British and American Foundry Practice. Frowde, Hodder & Stoughton, London. 4 sh. 6 d.

"In 1918 the author was sent by our Ministry of Munitions to the United States to study and report on American foundry practice, particularly as regards the use of sands for steel moulding. The present book gives an account of what he saw."—*Iron and Coal Trades Review,* Nov. 3, 1922.

Duponchelle, J. Comment on pratique la fonderie. 485 pp. 1921. Dunod, Paris.

Foundrymen's Handbook. 309 pp. 1922. Penton Publishing Co., Cleveland. $5.

Compilation of data, dealing with ferrous and non-ferrous foundry practice.

Hall, John Howe. The Steel Foundry. Ed. 2, 334 pp. 1922. McGraw-Hill Book Co., New York. $4.

Manufacture and properties of steel castings, and characteristics of various manufacturing processes.

Osann, Bernhard. Lehrbuch der Eisen- und Stahlgiesserei. Ed. 5, 693 pp. 1922. W. Engelmann, Leipsic. 950 marks.

Differs very little from edition 4, published in 1920.

Penton's Foundry List; a Directory of the Foundries of the United States and Canada, 1922-23. 1922. Penton Publishing Co., Cleveland. $20.

Rouelle, Jean. La fonte; élaboration et travail. 192 pp. 1921. Armand Colin, Paris. 5 fr.

Schwartz, H. A. American Malleable Cast Iron. 416 pp. 1922. Penton Publishing Co., Cleveland. $7.

Handbook of practice, dealing with properties, manufacture and uses.

Travelers Insurance Company. Safe Foundry Practice. Ed. 2. 85 pp. 1921. The Company, Hartford, Conn. Gratis.

Recommendations and suggestions based on long experience of the Engineering and Inspection Division of this company.

Verein deutscher Eisengiessereien. Giesserei-Handbuch. 264 pp. 1922. R. Oldenbourg, Munich. 300 marks.

Verein deutscher Eisengiessereien. Zur Geschichte der dteutschen Eisengiesserein; Festschrift zur funfzigsten Hauptversammlung des Vereins deutscher Eisengiessereien. 274 pp. 1921. Schwann, Dusseldorf. 100 marks.

Memorial volume, 1869-1920.

Vincent, M. Manuel du modeleur; construction des modèles de fonderie et dispositions de moulage. 334 pp. 1922. J. B. Baillière, Paris. 12 fr.

Whiteley, B. Ironfounding. 131 pp. 1921. Sir Isaac Pitman & Sons, New York. 3 sh.

Discusses materials and methods.

Fuels and Refractories.

Ashland Fire Brick Company. Bulletins. The Company, Ashland, Ky.

Non-technical, descriptive works, describing briefly such products as "Blast Furnace and Stove Linings," "Checker Brick," and "Firebrick for Forge Furnaces."

Bacon, R. F., and Hamor, W. A. American Fuels. 2 vols. 1008 pp. 1922. McGraw-Hill Book Co., New York. $8.

Comprehensive work dealing with technology, selection, and economy of fuels. Chapters on coke, powdered fuel, producer gas, etc., should be of special value to steel manufacturers.

Strassmann, P. G. Die Industrie feuerfester Steine und ihre Aufgaben fur Gaswerke und Kokereien. 1921. Deutsche Keramische Gesellschaft, Bonn. 10 marks.

Union Mining Company. Catalogue H, Pertaining to Fire Brick. 150 pp. n.d. The Company, Baltimore, Md.

Important technical data on refractories.

Wernicke, F. Die Herstellung der feuerfesten Baustoffe. Ed. 2, revised. Julius Springer, Berlin. 54 marks.

Heat Treatment.

Giolitti, F. Le traitement thermique préliminaire des aciers doux et demi-durs pour la construction mécanique; translated from Italian by Jean Galibourg. 524 pp. 1921. Dunod, Paris. 40 fr.

Groos, A., and Varinois, M. Traité théorique et pratique de cémentation; trempe, recuit et revenu. Ed. 2, revised. 126 pp. 1921. Albin Michel, Paris. 12 fr.

Guillet, Leon. La tremme et le revenu des produits métallurgiques. 264 pp. 1921. Octave Doin et Fils, Paris. 6 fr.

Massenz, Arturo. Lavorazione e tempera degli acciai; indurimento superficiale del ferro e cementazione. Ed. 4, revised. 214 pp. 1921. Ulrico Hoepli, Milan. 9.50 lire.
Heat treatment and cementation.

Menzel, E. Das Haerten, Schweissen and Löten von Stahl und Eisen nebst vielen Rezepten zur Herstellung praktischer Hilfsmittel. Ed. 3. 83 pp. 1921? C. Pataky, Berlin. 8 marks.

Simon, Eugen. Haerten und Vergueten. 2 v. Julius Springer, Berlin. (Werkstattbuecher, pt. 7-8.)

Sommer, F. Ueber die Vorgaenge beim Gluhen und Haerten von Eisen und Stahl. 24 pp. Stea-Verlagsgeselschaft fur Handel und Industrie, Solingen Böker-hof. 4.50 marks.

Urquhart, John W. Steel Thermal Treatment. 36 pp. Crosby Lockwood & Son, London. 36 sh.

UNITED STATES BUREAU OF STANDARDS PUBLICATIONS

Certain publications of the United States Bureau of Standards are listed below. They may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Circulars.

No. 113. Structure and Related Properties of Metals. 104 pp. 1921. 25 cents.

Scientific Papers.

No. 426. Thermal Expansion of Nickel, Monel Metal, Stellite, Stainless Steel, and Aluminum, by Wilmer H. Souder and Peter Hidnert. 497-519 pp. 1922. 10 cents.

No. 433. Thermal Expansion of a Few Steels, by Wilmer Souder and Peter Hidnert. 611-626 pp. 1922. 5 cents.

No. 448. Decarburization of Ferrochromium by Hydrogen, by Louis Jordan and F. E. Swindells. 327-334 pp. 1922. 5 cents.

Technologic Papers.

No. 203. Influence of Phosphorus upon the Microstructure and Hardness of Low-Carbon, Open-Hearth Steels, by Edward C. Groesbeck. 33 pp. 1921. 10 cents.

No. 204. Cutting Fluids, by Eugene C. Bingham. 76 pp. 1922. 15 cents.

No. 205. Tensile Properties of Some Structural Alloy Steels at High Temperatures, by H. J. French. 77-92 pp. 1922. 5 cents.

No. 206. Effect of Heat Treatment on the Mechanical Properties of 1 Per Cent Carbon Steel, by H. J. French and W. George Johnson. 93-121 pp. 1922. 15 cents.

No. 207. Manufacture and Properties of Steel Plates Containing Zirconum and Other Elements, by George K. Burgess and Raymond W. Woodward. 123-176 pp. 1922. 20 cents.

No. 209. Thermal Stresses in Chilled Iron Car Wheels, by G. K. Burgess and R. W. Woodward. 193-226 pp. 1922. 5 cents.

No. 218. Results of Some Compression Tests of Structural Steel Angles, by A. H. Stang and L. R. Strickenberg. 651-667 pp. 1922. 10 cents.

Transportation in the Steel Industry From an Engineering Standpoint

A Problem Not Easy of Solution—Many Expensive Surveys Have Accomplished But Little—Pittsburgh a Difficult Point, Due in Part to Misconceptions of the Tonnages Involved.

By F. L. EGAN

TRANSPORTATION is fundamentally nothing more and nothing less than an engineering problem. The steel producing district around Pittsburgh, Pa., has always been somewhat hampered for transportation facilities, due very largely to the physical characteristics of the district.

It is a fact, not generally known, that for the past 12 years there has each year been a rather expensive survey of some one or more outlets through which it was proposed to run railroad tracks for the purpose of relieving Pittsburgh's transportation poblem in some small measure.

Railroad Surveys Unproductive.

These surveys have invariably shown that the expense of securing right-of-way and the actual construction of the railroad would be so high as to be prohibitive. There is one privately owned railroad in the Pittsburgh district which cost approximately $1,000,000 per mile of right-of-way, and since this rather short piece of railroad was placed in operation, the result of its operation demonstrates that it will be a good investment.

Paradoxical as it may seem, it is a fact that as our larger railroad systems, such as the Pennsylvania, develop in size and become more complicated in the details of operation, the actual transportation which the railroad performs, that is, the moving of, say, a carload of freight from Pittsburgh to St. Louis becomes slower. A little study into the ways of railroad operation shows that where formerly the loaded car was moved from

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Pittsburgh to St. Louis with very little switching from one train to another, and possibly three transfers, at the present time the car will be transferred three times in order to get it out of the Pittsburgh district and it is very probable that the loaded car will be lost in one or more of the congested yards at transfer points, for many days.

Anyone who is familiar with railroad traffic conditions in and out of Pittsburgh since about the beginning of the world war, realizes that it is quite a common thing to have carload lot shipments completely lost for, in some cases, as much as 45 days, during which time neither the railroad company nor privately employed tracers of traffic are able to even locate the car, to say nothing of getting it in motion toward its destination.

What has been said is merely to recapitulate some of the disadvantages in transportation service with which Pittsburgh shippers have become inured.

Considering the entire situation from the viewpoint of an engineer to whom this transportation problem is given for solution, it is entirely natural and proper that he first make an investigation and obtain data upon the amount of tonnage which moves out of and into this steel producing district per year, considering and separating the tonnage into carload lots or larger shipments, and less than carload lots.

The result of such an investigation immediately shows very clearly that the freight congestion upon our Pittsburgh railroads is caused by carload lot and larger shipments, in many cases the shipments are *not carload lots, but trainload lots.*

At this point in the investigation or survey our engineer learns that he has received a problem fully large enough and important enough from a financial and operating standpoint to deserve and command his very best efforts.

Taking a comprehensive view of the entire situation, the first thing of major importance found is that the location of Pittsburgh furnishes a thoroughly practical and efficient solution of the problem of handling the transportation of very large tonnages, provided the natural facilities at hand are put to efficient use by the application of modern engineering, using practically the same methods which we would use in building and placing in operation a modern steel plant.

As this is written, the writer faces a map of the Pittsburgh district which shows the very congested area where the Allegheny and Monongahela Rivers join to form the Ohio. Radiating from this congested point are the three rivers and in the improvement of these three rivers the United States Government has spent many millions of dollars.

River Transportation.

The slack water system of the Monongahela River has been completed and any money which the government spends upon the Monongahela river now is for replacements, repairs, improvements, etc.

For each of the past three years, lock No. 3 on the Monongahela river has locked a tonnage considerably in excess of the tonnage which passed through the Panama canal for the same period.

If the amount of this annual tonnage on the Monongahela river is placed in comparison with the annual tonnage over the Ohio river for the same period, it is very evident that the Ohio river is not being used for transportation to even a very small percentage of its *present capacity.*

Why? You will find that there has been a large quantity of matter published, all pointing to the fact that the United States Government has not completed the slack water system of the Ohio river, but the United States Government has up to 1923 spent $68,000,000, from which it appears that it would be wise to make some efficient use of the improvements effected by this expenditure of money, *which we should keep in mind is our money, although it is expended by the United States Government.*

The commerce on the Monongahela has increased by bounds, in spite of the fact that its course is paralleled by railroads on either side. It is estimated that there is, on the average, a saving of $0.35 on a ton of coal when transported on the Monongahela river by the usual methods as compared with transportation by rail. This means that there was a saving to somebody of $4,200,000 in 1917, which amount would more than replace every lock and dam on the Monongahela, every three years, after deducting all operating and maintenance charges. The value of this improvement, therefore, cannot be challenged. This is a special condition and no river improvements in this country can stand a close mathematical analysis so well.

The wisdom of the expenditures of large sums of money by the United States Government for the improvement of our rivers cannot be disproved, providing of course, proper use is made of the improvements after they are completed.

When the situation and all its conditions are analyzed in a cold blooded way, it is found that the Ohio river cannot be used in its present condition by certain old towboats and packet boats constructed anywhere from 18 to 35 years ago, most of which have been abandoned and later resurrected and placed in service to render efficient transportation, not taking into consideration that these boats were obliged to discontinue operations many years ago at a time when common labor in Pittsburgh was $0.85 a day and coal was delivered to the bunkers of the South Side works of Jones & Laughlin Steel Company at $0.90 a ton. Is it any wonder that these old boats are not a success at this time when basic costs are very much higher, and it is necessary to secure the utmost efficiency in every detail of any commercial enterprise which is to be successful? Most of these old boats require a depth of water in the channel, in excess of the depth at which it is economical to load and move barges up and down the Ohio River.

One of our American humorists has said: "It is better not to know so darn much than to know so darn much that ain't so." This quotation expresses in the minimum number of words the most important difficulty with river transportation as it has been and is being applied to our Pittsburgh district transportation problem.

Getting down to the facts and details in the production of steel mill products in the Pittsburgh district and their transportation to the market, our Pittsburgh manufacturers must realize that the amount which the consumer pays is the value which controls the business. "Pittsburgh base" is all right as a basis for figuring, but it is all wrong when it comes to marketing your product, if transportation charges, which are excessively high, must be included.

From statistics compiled by "The United States Railroad Administration," the railroad corporations of this country have a bonded indebtedness which averages a little over thirty thousand dollars ($30,000) per mile of main line track, upon which bonded indebtedness the railroads pay an average rate of interest and charges of slightly over 5 per cent per annum.

It is possible by using modern river transportation, properly engineered, to attain an average ton mile cost (including all legitimate charges for a round trip between Pittsburgh and New Orleans) which is less than the interest and charges, upon their bonded indebtedness, that the railroad corporations must include in the expense charged to each ton they transport.

Several of the highest salaried railroad executives we have in the Pittsburgh district have made a careful study of the engineering analysis upon which this statement is made and they have decided and state positively that "there is no railroad which can compete with river transportation using modern methods properly engineered."

The railroads and a modern river transportation project, each have an important service to render to the shipper; they are not competitive. The railroads are now realizing this fact and are even offering to co-operate with a properly engineered and operated river transportation project.

First River Shipments of Steel.

On April 3, 1922, the Jones & Laughlin Steel Company sent a tow consisting of eight steel barges pushed by the stern paddlewheel towboat "Aliquippa." The barges were loaded with pipe and other manufactured steel products and the tonnage was destined for Louisville, Ky., Evansville, Ind., St. Louis, Mo., and Memphis, Tenn. Since the departure of its first tow the steel company has sent many thousands of tons of steel pipe, wire products, plates, bars, shapes and other commodities to cities situated on the Ohio and Mississippi rivers. Other steel companies situated in the Pittsburgh and Wheeling districts have made similar moves to effect the transportation of their products over the Ohio and Mississippi rivers. Moving tonnage in this way upon our western rivers is very much more economical than moving the same tonnage by rail and *still the operation costs more than four times what it should cost.*

The moving of tonnage upon the rivers works out quite successfully, and some of our river transportation companies show fair returns upon their investment as long as they confine themselves to downstream operations. When an attempt is made to move loaded tows upstream, the ton mile cost becomes exorbitant.

Why? Because the radial stern wheel, as a propelling unit, has a maximum efficiency of 36 per cent when the thrust required from it is very low, and the efficiency goes down very rapidly to 12 per cent when the thrust required from it is increased to maximum values as is necessary in moving a loaded tow upstream against any appreciable current.

The radial stern wheel, in combination with the three balanced rudders used with it, *is very efficient as a means to steer a loaded tow downstream,* but the transportation of tonnage upon our rivers consists of something more than steering a fleet of barges downstream. It requires very large thrust values to move heavily loaded tows upstream against the currents in the Ohio and Mississippi rivers. The radial stern wheel boat fails completely in heavy upstream towing, because it cannot deliver the required thrust values.

About the year 1889 water traffic on the Mississippi reached its peak. In that year there were transported between St. Louis and New Orleans 844,000 tons, while in 1908 the tonnage for the year had fallen to 88,500 tons. If you are really interested in this transportation problem *make a note at this point* and take the trouble to find out the tonnage moved between St. Louis and New Orleans by "The Federal Barge Line" for each of the past three years. Write Theodore Brent, Federal Manager, Mississippi-Warrior Service, Federal Reserve Bank Building, St. Louis, Mo.

A large part of the tonnage that was formerly handled upon the Ohio and Mississippi rivers consisted of coal from the Pittsburgh pools and most of it went through to New Orleans.

The barges in use at that time were usually built for a single trip and after unloading at New Orleans or other lower river ports, they would be sold for the timber or lumber which they contained. These barges, or coal boats, as they were called, were so lightly constructed that it was quite common for the tow to strike a snag or shoal and sink the entire fleet of barges.

Early Misconceptions.

Some years previous to the world war, the pride of the Mississippi and Ohio rivers was the steamboat "Sprague" and a large fleet of coal boats which was used for transporting coal down the Ohio and Mississippi rivers from Pittsburgh to New Orleans. This huge stern wheel steamer has a power plant which was designed to develop 2,500 hp. when the engines were making 16 rpm. The designers of the "Sprague" went so far astray in adapting the power plant to the stern wheel at its actual operating efficiency that her engines have never in the history of the boat made over 12 rpm. and she has done all her towing work at 9 rpm. When the "Sprague" was in the coal trade described above, she would have lashed to her as many as 56 coal barges loaded with from 40,000 to 50,000 tons of coal, wait for a freshet or high water on the rivers and set off downstream from Pittsburgh like a floating island, almost six acreas in area. Barges were taken off at various points on the way to New Orleans, although usually the entire tow was scheduled for New Orleans. In a great many cases this boat would lose a large percentage of her tow (by the sinking of the coal barges) by the time she reached New Orleans. At one time she made three successive trips and arrived in each case without any of her tow being left. On the third and last trip she was in charge of Captain "Cal" Blazer, who is at present captain of one of the Carnegie Steel Company's Monongahela river towboats. Upon this trip the "Sprague" sank her entire tow of 51 barges, due to striking a shoal. The barges were all sunk and the coal was lost less than eight hours running time above New Orleans. *This is the old line river transportation about which we hear so much that is not true and which the old line river operating man fondly hopes to see return.*

Some of the companies who have become interested in river transportation have not taken into consideration that in the old days river transportation consisted of making up a tow and *steering it down the river* with a boat

Analysis of the difficulties which have limited the free development of transportation through and about the Pittsburgh territory.

Comprehensive visualization of the possibilities of the near future, and constructive suggestions for the line of attack which offers the best solution of this increasingly difficult problem! so vital to Pittsburgh Progress.

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like the "Sprague" and the tonnage finally arrived at New Orleans, *sometimes*. A towboat like the "Sprague" had to make the entire return trip with empty barges and in case of what our river men call a big river, that is, high water, she could not then and cannot today do more than push herself upstream at certain points in the Mississippi river. In fact, the captains and pilots who have had years of experience on some of these old stern wheel boats have a rather common expression which they use in describing portions of upstream trips. The expression is: "We had dinner and supper in the same place," meaning that although the towboat exerted the power of which she was capable, little or no headway was made during a six-hour watch.

Due to the very large losses resulting from the above described methods and on account of the inability of the radial stern wheel towboats to push tonnage upstream profitably, the barge traffic had been largely discontinued until in August of 1910 the United States Government sent a committee of engineers to study river transportation in Europe, and as a result of the findings of this committee made comparative tests of the stern wheel and twin screw, tunnel stern towboats, and decided to use the twin screw, tunnel stern towboats for government work wherever possible.

Governmental Influence.

The practical result of the work of the engineering committee mentioned above is a United States Government project generally known as "The Federal Barge Line" which operates between St. Louis and New Orleans.

When the United States Government decided that this country would become involved in the world war, the director general of railroads commandeered all river craft privately owned and made provision for the construction of barges and towboats. This action was the start of "The Federal Barge Line."

One of the towboats taken over by the director geneal of railroads was the towboat "Sprague" mentioned above. The "Sprague" was originally built for the River Coal Company of Pittsburgh. Upon taking over the "Sprague" the United States army engineers made an earnest, conscientious effort to operate her successfully and failed, because she would not push tonnage upstream due to the low efficiency of the stern wheel and also because the cost of operation and upkeep, including the cost of the time she was out of service for repairs, proved beyond any question of doubt that the "Sprague" and towboats of that type are at the present time an *economic impossibility.*

In the meantime "The Federal Barge Line" had built and now has in service about 40 barges, each of 2,500 tons capacity, and six twin screw, tunnel stern towboats of the "Natchez" class. These towboats have a rating of 1,800 indicated horsepower and regularly push a tow of 12,000 tons paying load downstream and about 8,000 tons paying load upstream between St. Louis and New Orleans. The schedules call for two sailings a week from each port, deliveries downstream being made in five days and upstream in 12 days. The freight rates charged by "The Federal Barge Line" are approximately 80 per cent of the Interstate Commerce Commission rail rates for an equivalent service.

Conclusions.

The entire river route between Pittsburgh and New Orleans has been very thoroughly and carefully surveyed and analyzed with the intention to determine the best possible methods to adopt in order to move tonnage both up and down stream in the most efficient way.

In detail it was:

First—necessary to determine the most efficient propelling unit and then the practical application of such propelling unit to the *conditions which exist upon the Ohio river at this time.*

The answer to this problem is in one sense very simple, that is, it is easy to determine the most efficient propelling unit which is for high thrust values a scientifically designed four-bladed screw propeller having a large area ratio. The practical application of such a propelling unit to the conditions which exist upon the Ohio river at this time is the difficult part of the problem and this has been answered by a close co-ordination in the design of the tunnels, the screw propellers and the rudders, including their relative positions to each other.

Second—To determine the best possible way to coordinate the judgment and decisions of the pilot (with the proper and efficient handling or maneuvering of the tow) to the propelling unit. Investigation into this matter has shown that a very large expense in the transportation of tonnage upon our rivers has been caused by a lack of coordination between what the pilot decides should be done and the actual accomplishment, due to the introduction of an additional human element and faulty systems of communication between the pilot house and the propelling unit. This problem has been answered by placing the entire control of the towing unit directly in the hands of the pilot with the result that he alone is responsible for the operation and safety of the entire unit.

Third—Having accomplished the above purposes an efficient means of generating and distributing the power of the towboat was necessary. Going back to our very first statement, "Transportation is fundamentally nothing more and nothing less than an engineering problem," having fixed a value for the shaft horsepower of the towboat, it then became necessary to design a power plant which would not only generate the required power with the very highest attainable efficiency, but would also lend itself readily to the distribution of this power and the maneuvering of not only the main units upon the towboat, but also all of the auxiliaries, even including the ordinary conveniences such as washing machines, vacuum cleaners, etc. The above requiements have been filled by discarding the methods which have been in common use and reverting to the fundamental principles of engineering design to produce a power plant of the required capacity, having the highest attainable efficiency considering first cost, maintenance, operating expense and flexibility. In addition to the above, it has been necessary to keep constantly before the engineers engaged on the work that the completed towing unit must lend itself readily to any changes which might be dictated by further advances or improvements in the efficient generation and distribution of power.

The survey analysis and the engineering of the entire matter has been conducted so carefully and in such detail, and the results have been checked from different angles by the best available talent so there can be no question as to the ultimate success of the work.

River transportation in a modern efficient form is available to the larger shippers, adjacent to the Ohio and Mississippi rivers, provided the shipper will make use of a solution of his transportation problems which has been attained by the same methods used by the steel companies to produce manufactured steel at the lowest possible cost.

One Hundred Per Cent Safety For 1923

Safety Not Yet an Exact Science—Definite Underlying Principles When Applied Consistently, Conscientiously and with Whole-Hearted Co-operation Will Effect Marvelous Results.

By JOHN A. OARTEL*

TO the hard headed, practical blast furnace or steel mill man my topic may seem visionary and impractical, yet I hope to prove to that same practical man that this ideal is neither visionary nor impossible of attainment. It has been accomplished in certain blast furnace and steel plants during 1922 and a standard has thereby been set up that is at least worthy to aim at.

There is no one so rash as to say that safety is an exact science in its present stage of development. It is yet too new in industry to attempt to lay down certain principles and say that they will work under any and all conditions. There have come, however, certain observations to the writer that have led him to believe very strongly in some underlying principles which, if applied, cannot fail to produce results in accident prevention which to the "old timer" will seem little short of marvelous. These principles can be told better by illustrations than in any other way.

The Interest of the Manager.

The whole hearted interest of the manager is necessary in a plant that desires to realize 100 per cent safety. Not long ago, a series of safety lectures for the foremen of a large steel plant were inaugurated as a part of the safety program. The lectures were given in a large auditorium in the mill town. A man was secured for chairman and leader of the meetings who not only possessed leadership, but also a fine fund of wit and humor. A splendid entertainment was given at each meeting and the best safety speakers the country affords were on the program. Each evening the hall was crowded to capacity and many were turned away. Since the conclusion of the lecture course this plant has led all the other plants of the same company in safety. The reason for the success of the meetings and the good resulting therefrom did not come from the chairman of the meetings, the speakers or the entertainment furnished. The success came because the general superintendent of the plant attended each one of the meetings. He stood in the lobby and shook every man's hand as he entered and his department superintendents acted as ushers and directed the men to their seats. With an example like that, is it any wonder that practically every employe of that plant is a booster for safety?

The writer one day went into a steel plant to transact some business with the safety engineer, who had his office at the emergency hospital. On his way there he noticed a man running in the direction in which he was going. Pretty soon the man caught up to him and passed him and as he passed he called out, "I wish I had your long legs, so that I might run faster," and passed on. There were two men at the emergency hospital who had been gassed and the man who ran so fast was their department superintendent and he ran because he was anxious to ascertain their condition as quickly as possible.

Co-operation and Leadership of Foremen.

The interest of the man higher up, however, will not bring results unless the foremen co-operate and use the leadership which they possess to promote safety. The foreman stands between the management and the men. He represents the company to the employes. In a great many instances the workman knows nothing about the company except what he learns from his foreman. If the foreman is kind, agreeable and helpful, the workman receives a good impression of the company. If, on the other hand, the foreman is harsh, disagreeable and a "driver," the impression received by the workman is anything but good.

Presuming that the foreman is of the first type described and that he has secured the workman's confidence by kind treatment, he will have little difficulty in imparting and securing a hearing for the safety message.

A Foreman's Duty.

There are several specific things a foreman can do to promote safety.

(1) Special care should be exercised for the new employe. From accident statistics we learn that accidents occur to new employes in the ratio of six to one compared to the workmen who have been some time on the job. Therefore, the fullest instruction in safety should be given to the new man. Very often he has just landed on our shores from an agricultural environment in Europe or Asia where he has perhaps never seen a locomotive or a manufacturing establishment. In two or three weeks from the time he leaves home he is set down in a mill or a manufacturing establishment where there is the splash of molten metal along with the rush and roar and noise of moving machinery. He gets confused and meets with an accident. Who is to blame, an ignorant foreigner or a foreman who is too careless or too indifferent to spend a little time in giving adequate safety instructions?

In a steel mill, not long ago, a gang of painters was sent to the roof of a building to paint it. Instead of the foreman going to the roof of the building in advance of his gang to investigate the hazards, he simply told the men to go up on the roof and paint. There was a 6,600-volt wire strung along the roof of the building. One of the men came in contact with it and died. Who was to blame, an ignorant Greek painter or a careless foreman?

(2) Another duty of the foreman is to look out for the old employe who persists in dangerous practices. Men who have been doing a certain work for a long time become so familiar with it that their work is ofttimes done with very little thought for the dangers that may be inci-

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*Chief of Bureau of Safety, Carnegie Steel Company, and Vice-President in charge of Industry, Western Pennsylvania Division, National Safety Council.

dent to it. The blast furnace man learns to "eat gas;" the open hearth man scorns to wear goggles and leggins on the pouring platform and neglects to lower the tap hole shield while digging out the dolomite previous to tapping the heat. The rolling mill man prides himself on his ability to dart in and adjust a guide before another piece comes along. The railroader has stood in the middle of the track and stepped on the footboard of an approaching locomotive successfully during his entire service as a brakeman. Notwithstanding these successful flirtations with death, these same dangerous practices have gathered a toll of life and limb month by month and year by year.

A foreman whose ideal is 100 per cent safety will break up these dangerous practices. In a certain steel mill there is a transportation department whose superintendent is very much alive regarding dangerous practices. All who engage in them are called into the office and cautioned, reprimanded or disciplined according to the seriousness of the case. All this is done in a friendly spirit, yet with due regard for the dignity of safety. The consequence is that accidents in this department have been reduced to a minimum. The foreman may, therefore, by a study of his men, by kind treatment of them at all times, by firmness when necessary and by constant watchfulness lead his gang to a high degree of efficiency in safety.

The Attitude of the Workman.

The last factor for 100 per cent safety in a plant is the workman himself. He may be illiterate, ignorant, indifferent and "hard boiled," yet a lasting impression can be made upon him if the manager manifests an interest in safety and demonstrates it and if the foreman exercises his leadership in the right way. The writer knows of a steel mill that is the last word in safety as far as construction and safeguarding are concerned, yet the accident rate is high. On the other hand, he knows a plant with old time construction where the accident rate is low. In the up-to-date plant no attention is given to the instruction and education of the workman in safety, while in the old time plant the superintendent takes a special interest in safety.

One hundred per cent safety is not a dream or a fiction of the imagination. It has been demonstrated frequently enough to prove that it is a possibility. It is not easy of attainment, for there is no "royal road" by which it may be reached. It comes only through the "fasting and prayer" known to the industrial man as hard work.

There are two branches in the life saving service of our country. One is the Coast Guard Service, composed of a body of brave and fearless men whose own lives are frequently sacrificed to save the lives of others. Day and night, in sunshine and in storm, they are on the alert, ready to put forth to battle with wind and wave to rescue the shipwrecked mariner. The other branch is the Light House Service, that faithful body of men who dwell in loneliness on rockbound coasts far from the haunts of men. They dwell there, giving their lives in service in order that the warning light may stream across the wave and give its message to the seaman who approaches too close to the dangerous shore. So, in the safety work there are two bodies of men, whose untiring efforts are helping to minimize and to prevent industrial accidents. One body is composed of industrial surgeons, whose devotion to their work and whose surgical skill has snatched a multitude of men from the brink of the grave. The other is the safety man, be he safety engineer, sueprintendent, foreman or ordinary workman, whose untiring zeal, wise planning and efficient execution have made our industrial establishments a safe and pleasant place for the workman.

RESEARCH ON THE CORROSION OF STEEL PIPE

The National Tube Company of Pittsburgh, Pa., has announced the establishment of an Industrial Fellowship in the Mellon Institute of Industrial Research of the University of Pittsburgh, Pittsburgh, Pa.

This Industrial Fellowship is engaged in a systematic study of practical methods for the prevention of corrosion in hot water supply systems. It is also giving attention to the classification of waters of various chemical composition, with respect to their relative corrosive action upon iron and steel, particularly in the form of pipe lines, boiler economizers, tubes, etc.

The present incumbent of the Industrial Fellowship is Mr. Clifford R. Texter, who for the past several years has been carrying out research on the corrosion of iron and steel, where not exposed directly to the atmosphere. Mr. Texter will be glad to correspond with engineers and manufacturers interested in the field to which his Industrial Fellowship relates.

The National Association of Cost Accountants has a limited number of copies of the following official publications. They are available to non-members of the association at a price of 75 cents per copy. Remittance must accompany all orders.

Volume I

No. 7—"Accounting for By-Products," Research Department, N. A. C. A.

Volume II

No. 7—"Purchase Orders and Purchase Records," Homer N. Sweet.
No. 9—"Cost Accounting for Public Utilities," E. D. Bistline.
No. 10—"A Bibliography of Cost Books," Research Department, N. A. C. A.
No. 15—"What Is Wrong With Cost Accounting," G Charter Harrison.
No. 16—"A Method of Distributing Factory Payroll," Matthew Porosky.
No. 17—"Coal Production Costs," R. W. Gardiner.
No. 18—"Uniform Cost Accounting Methods in the Printing Industry," Lawrence.
No. 19—"Cost System for an Electric Cable Plant," F. Benke.

Volume III

No. 4—"Some Cost Problems in the Hawaiian Sugar Industry," F. A. Haenisch.
No. 6—"Some Problems of Cost Accounting in the Chemical Industry," Rose.
No. 7—"Cost Accounting in the Soap Industry," Wm. C. Koch.
No. 9—"Method of Accounting for Waste in a Cotton Spinning Mill," Klim.
No. 10—"List of References on Interest as an Element of Cost."
No. 11—"The Scrap Problem," F. W. Kokins.
No. 15—"Flour Milling Costs," C. A. H. Narlian.
No. 16—"Distribution of Operating Costs of Centralized Power Plants at Low Capacity," Wolfe.
No. 19—"Normal Burden Rates," Charles Van Zandt.

Volume IV

No. 3—"Proceedings of the First New England Regional Cost Conference."
No. 4—"Cost Accounting in the Manufacture of Iron and Steel Sheets."
No. 5—"Steamship Operating and Terminal Costs," U. Roberts and J. J. Mulhern.
No. 6—"Cost Practices and Problems in the Production of Coke," Sheppard.
No. 7—"Accounting for Production Costs in the Manufacture of Phonograph Records," E. J. Borton.

By-Product Coking During the Past Year

Smallest Twelve-Month Total of New Construction in Last Decade—Many Vital Improvements in Oven Design—Brighter Prospects for the New Year.

By **C. J. RAMSBURG***

DUE to the general business depression in 1921 there were fewer ovens put in operation in 1922 than in any year in the past decade, the available figures showing that only 80 ovens were put into operation during this year.

Company	Location	Ovens	Type
Milwaukee Coke & Gas Co.,	Milwaukee, Wis.	50	Koppers
Alabama By-Products Corp.,	Birmingham, Ala.	25	Koppers
Chicago By-Product Coke Co.,	Chicago, Ill.	5	Koppers
	Total	80	

This lack of new building, however, was more than offset by the improvements and developments which took place during the year. There was put into operation at the plant of the Chicago By-Product Coke Company a battery of five ovens of a new type developed by the Koppers Company. The results secured from these ovens indicate that this design is the greatest step forward since the by-product oven was introduced in this country, as it has apparently met the two objects at which by-product coke oven designers have been aiming for years; namely, increased capacity per oven unit per day and the production of better grade blast furnace coke.

The writer will not endeavor to go into detail regarding the design of this new oven, as this has been covered very thoroughly by Mr. Joseph Becker in an article which appeared in the November issue of "Blast Furnace and Steel Plant." It is sufficient to say that since beginning operation, the five ovens at Chicago have been on a coking time of between 10 and 11 hours and have been operated on as low a coking time as 9 hours, 30 minutes, all of which has been accomplished with flue temperatures not exceeding 2600 deg. F. These ovens have a capacity of 12 tons per charge, and on a 10-hour coking basis carbonize approximately 29 tons of coal per oven per day.

Construction Orders for 1923.

On the strength of these results, the designers of this oven have received orders covering the construction of two plants totalling 403 ovens of this type, 366 of which are for Carnegie Steel Company at Clairton, Pa., and 37 for Weirton Steel Company, Weirton, W. Va. The new plant at Clairton is in addition to the 768 Koppers ovens already in operation there, and when these new ovens are completed this plant will have a capacity for carbonizing over 22,000 tons of coal per day. The 37 ovens at Weirton are designed to carbonize 1,000 tons of coal per day, or at the rate of 27 tons per oven per day.

When it is considered that of the ovens built in the last 10 years very few, if any, have a carbonizing capacity of over 20 tons of coal per day, this achievement is quite remarkable and is of great value to the iron and steel industry.

Low Btu. Gases for Oven Heating.

Another development of vital consequence to the iron and steel industry has been in heating by-product coke ovens with producer gas. In another part of this issue there is an article by W. Reed Morris, Assistant Superintendent of the Seaboard By-Product Coke Company, which gives very complete information on this general subject, together with comparisons as to the results secured when operating with producer gas and blue water gas. From these figures it appears that where there is the possibility of choice between blue gas heating and producer gas heating, the use of producer gas is much to be desired.

The other plants besides the Seaboard By-Product Coke Company where producer gas has been used for heating the ovens with excellent results are:

Camden Coke Company, Camden, N. J., where they have 37 Koppers' Combination Ovens and four Koppers Kerpely Producers.

Providence Gas Company, Providence, R. I., where they have 40 Koppers Combination Ovens and U. G. I. producers.

The use of low Btu. gases, such as producer gas or blast furnace gas, will undoubtedly become more and more prevalent in future installations, which means that the combination oven, which can be heated with either producer gas, blast furnace gas, blue water gas or coke oven gas, will be the type of oven to be built. All of the ovens contracted for in 1922 are of this construction and it is very doubtful if any steel company will build ovens in the future which cannot be heated with these low Btu. gases. While there are no plants in this country operating with blast furnace gas, there are quite a number of such plants in Europe, and the available figures show that excellent results can be secured.

Another development which will be watched with great interest is the adaptation of the liquid method of gas purification to the needs of the iron and steel industry. The Pittsburgh Crucible Steel Company has taken the lead in this matter and have contracted with the Koppers Company, who are the inventors of this process, to build for them a 12,000,000 cu. ft. plant at their Midland Works for the purpose of purifying their coke oven gas to permit of its use in their open hearth furnaces.

This process for purifying gas has as its principle of operation the use of a dilute aqueous solution of sodium carbonate or soda ash to remove H_2S from the gas by scrubbing contact with it. This method of gas purification has met with great approval in the gas industry, a number of plants having been put into operation during the past year, while others are now under construction.

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*Vice-President, Koppers Co., Pittsburgh, Pa.

New Construction During Past Year.

The only new oven construction contracted for during 1922 are the plants above mentioned; namely, the Carnegie Steel Company, Clairton, Pa., 366 Koppers ovens and Weirton Steel Company, Weirton, W. Va., 37 ovens. It is very probable that under the stimulus of the important development of the past year, a number of ovens will be built or contracted for in 1923.

On the whole the by-product coking industry has reason to congratulate itself on the splendid showing that it has made during the past decade. The production of coke from this source has grown from approximately 18 per cent of the total coke produced in 1912 to over 80 per cent in 1921. Experience of the past two years has clearly shown that the beehive oven has been relegated to a place where it can only be used to advantage during boom times. It is significant to note in this connection that in November, 1922, there was more by-product coke produced than in any previous month during the history of the industry, approximately 3,000,000 tons having been produced as compared to approximately 1,000,000 tons of beehive coke.

The value of operating by-product coke plants in connection with iron and steel plants was never more conclusively demonstrated than during the period of business depression just passed. This is due to the increased use of coke oven gas and tar in the steel mills and the great flexibility possible in the operation of the by-product coke plant, it being a simple matter to adjust operations to meet the varying demands of the industry for coke and by-products.

*Dry Cooling Process of Coke**

Disadvantage of Wet Cooling of Coke—Specific Heat of Coke—Making Use of the Heat of the Hot Coke—Description of Experimental Plant of the Firm Gebruder Sulzer, of Schlieren, Zurich.

By DR. P. SCHLAPFER

THE scarcity and the high price of fuels during the war made it necessary to utilize heat in the most economical manner. Many trials have proved a failure as the savings of fuels did not correspond with the costs of erecting the plant or with operating expenses. Up to this date coke was cooled or quenched by water, when it is pushed out of the coke ovens at about 1,000 deg. C. The installations for cooling coke in this manner have lately been very much improved. In spite of this the wet cooling process has many disadvantages. The coke will crack into small pieces with formation of small coke and dust, which means a decrease of value. Further it is impossible to quench the coke uniformly. The content of water may vary between rather wide limits and will amount to at least 5 per cent with careful quenching.

In case the coke is used by the producing firm, the evaporation of the enclosed water will need at least considerable heat, and the consumption of fuels at the blast furnace or in the generator will naturally increase. In sending the coke to other plants, the excessive freight rates for the water, which is contained in the coke, have to be paid. Besides in quenching coke there will always be developed sulphurous acid which will corrode those parts of the quenching apparatus which are exposed to the vapor. It is obvious that a process which will produce dry cool coke will be welcomed. H. Wunderlich drew attention to the fact in 1921 that the loss of heat units by quenching the coke is very great.

Comparative Coke Production.

In Austria and Germany about 32,000,000 tons of coke were produced in the year 1912. Suppose that the coke is pushed out of the ovens at a temperature of 1,000 deg. C., and cooled down to about 260 deg. C. and at a mean specific heat of the coke of 0.38, the coke generates about 880 lb. steam, at a consumption of 22 lbs. steam for 1 hp. each ton of coke can develop 40 hp. Since the heat is consumed by quenching water, there will be wasted more than 1,280,000,000 hp. a year in both countries. In 1921 about 23,000,000 tons of coke were produced in the United States; 21,000,000 tons in Great Britain and 28,000,000 tons in Germany.

Very little can be found in literature about the specific heat of coke. It is safe to say that it varies from 0.33 to 0.38 and I have found the specific heat in coke with 10.5 per cent ash to be:

Temperature, Deg. C.	Mean Specific Heat
18 — 100	0.214
18 — 400	0.273
18 — 477	0.286
18 — 577	0.305
18 — 800	0.333

Several methods have been put into practice for the recovery of at least a part of the sensible heat of coke. (1) Using the gases in specially designed furnaces for the production of water gas. (2) The use of indifferent gases, which, after being drawn through the hot coke are enabled to deliver their heat to some distant point, as for instance, the generation of steam in proper steam boilers.

The firm of Gebruder Sulzer has won marked success in waste heat boiler development, and their results furnish reliable data and information upon which commercial conclusions can be reached.

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*Translation of article in "Stahl und Eisen" of August 17, 1922, by H. Illier.

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Experimental Plant at Schlieren.

The coke as pushed out of the retorts or chambers of a coke oven is brought in buckets T, Fig. 1, from the coke oven plant to the cooling furnace or furnaces K, which can be closed so tight that no air may enter. Adjacent to these furnaces are situated the boilers D. By an exhauster V of special design, the gases are circulated through the whole system till the coke is cooled to about 250 deg. C. After the furnace is filled with hot coke, the oxygen, which has entered with the coke, will soon be consumed and will be changed to carbon dioxide and carbon monoxide. If the furnace is air tight no more air is admitted and the coke will not burn up. The coke oven is filled up and drawn at intervals so that steam is generated continually. This first plant has been erected at the gas works at Schlieren, Zurich, for experimental purposes and does not claim to be a model plant. It has been running now for 2½ years and gives entire satisfaction. In 1920 a trial for testing the effect was made during 24 hours and the following data was ascertained:

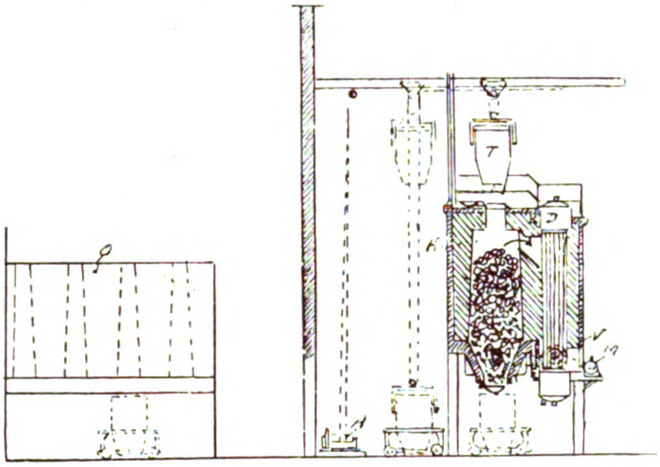

Fig. 1—Experimental plant at the gas works at Schelieren Zurich for the dry cooling of coke.

Volume of coke furnace........	353 cu. ft.
Heating surface of boiler.......	1,226 sq. ft.
No. of emptied retorts.........	66
Weight of coke, net...........	49,192 lb.
Weight of coke of each retort...	745.5 lb.
Feedwater	24,096 lb.
Mean steam pressure..........	76.8 lbs. per sq. in.
Heat units of 1 lb. coke........	545

The temperature of the hot coke was measured by a pyrometer. It was about 1,000 deg. C. Probably the figure is too low. During the trial the gases were analyzed and gave the following results:

	Minimum Per cent	Maximum Per cent	Analysis before drawing the cold coke. Per cent	Analysis after filling up the hot coke. Per cent
Carbon dioxide	11.0	16.0	14.1	11.4
Oxygen.......	0.0	3.6	1.1	0.6
Carbon monoxide	0.8	15.4	2.4	15.4

The gases are poorer in oxygen, the warmer the coke is. The amount of carbonic acid and carbon dioxide depends also on the temperature of the coke.

In filling up part of the carbon dioxide is reduced to carbon monoxide after the equation $CO_2 + C = 2CO$. The content of carbon monoxide increases considerably in the beginning of the cooling period. As soon as the temperature of the hot coke decreases, part of the carbon monoxide can again burn after the equation $CO + O = CO_2$, on behalf of the fresh air that enters the furnace at each filling up. If the coke would burn in the furnace a great amount of heat would be generate d,since coke generates 13,000 heat units while burning, against 450-630 while cooling. This is also proven by measuring the temperature of the gases as shown in Fig. 2. The temperature will quickly rise to 750 deg. C. after filling up and slowly fall to 280 deg. C. If a continual combustion would take place, the curve could not have the sharp points.

The daily reports of the plant were recorded from November 26 to December 12, 1921. On the average 23.6 tons of coke were cooled daily and 9.4 tons of water of 50 deg. C. evaporated to steam of 90 lb. per sq. in. pressure. During a period of 285 days 7,630 tons of coke were cooled and 2,922 tons of steam generated, that is 0.383 tons of steam for one ton of coke

Careful Handling Necessary.

In erecting new plants care must be taken that the coke will be handled as little as possible in order not to produce too much small coke and dust. For this reason the very best facilities for transportation of the coke to the cooling plant have to be designed. The firm of Gebruder Sulzer has gained much experience at the experimental plant. The furnace, for instance, is built in a special manner in order that the coke will glide down without much friction and without forming a bridge and will be cooled evenly. The heating surface of the boiler has to be in the right relation to the furnace. Since it has been proven that the development tendency shown by Gebruder Sulzer is successfull, and that it is possible to gain 0.35 to 0.4 lb. of steam for each lb. of coke of 1,000 deg. C, it is now a matter of calculation to determine whether this process will pay. It has to be taken into consideration whether the opportunity is given to make use of the generated steam with the elimination of present steam boilers. In conclusion several cooling plants which are either erected or planned will be described.

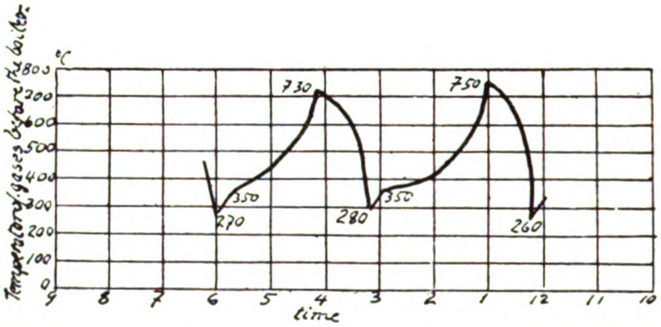

Fig. 2—Temperature of circulating gases. Time of cooling three hours.

Fig. 3 shows a plant for a gas works consisting of a battery of inclined chambers. Each chamber contains 11,000 lbs. of coke, which is caught by the box K and hoisted over the cooling furnace and fed through the hopper e. After cooling, the coke is drawn into the coke car f.

A cooling plant is being erected for a coke plant with horizontal chambers for a production of 150 tons of coke daily. As in the former case, the new installation had to be adapted to the existing arrangement. Up to this date 6,600 lbs. of hot coke was pushed into a special car and conveyed to a quenching tower fitted with an elevator. The coke car was lowered into a basin of water. After being cooled the coke was hoisted and the car emptied into the cooling furnace.

A cooling plant for two coke batteries of a daily production of 1,000 tons, each battery has 70 chambers of 8 tons capacity each. The cooling plant contains four furnaces, of which three are working and the fourth is in reserve. The plant is served by two elevators, which are connected with each other by a bridge. The hot coke is pushed into deep cars with inclined bottom and side door and is transferred to the elevators by a small engine. Each elevator can handle the whole output. Under the furnace is situated a conveyor by which the coke is delivered directly into a special car and conveyed to the coke separator. It is estimated that the whole amount of steam, which is necessary for the coking plant and the necessary electric power can be furnished by the sensible heat of the coke. For this purpose the boilers are fitted with superheaters for a working pressure of 210 lbs. The steam is first used in a turbo-generator and the low pressure steam for various other purposes. In order to control the evaporation of steam, the exhaustor, which handles the gases, is driven by an electric motor, whose speed can be varied between wide limits. This regulation is done automatically by the pressure of the steam in the boilers.

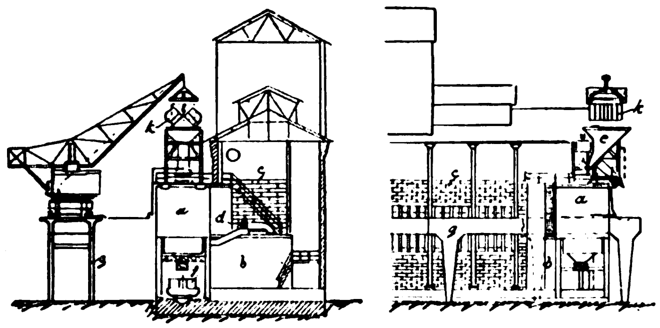

Fig. 3—A plant for a gas works consisting of a battery of inclined chambers, each battery contains 11,000 lbs. of coke which is caught by the box K and hoisted over the cooling furnace and fed through the hopper E. After cooling the coke is drawn into the coke car F.

NEW GAS PRODUCERS FOR FORD PLANT

The Smith Gas Engineering Company, Dayton, Ohio, is now building for the Ford Motor Company's Highland Park Plant three 16 ft. mechanically operated clean gas producers which will add to the present capacity of their plant which is the largest clean gas producer plant in the world. They are now making approximately 45,000,000 cu. ft. of clean gas per day and with the additional equipment building will have a capacity of 60,000,000 cu. ft. per day. This gas is used for the development of power and for a great many industrial heating operations, such as forging, heat-treating, tempering, brazing, soldering and the like which are commonly found in the automobile industry.

The Smith Gas Engineering Company also announce that they have recently appointed the Vincent-Gilson Engineering Company, 30 Church Street, New York, as eastern representatives and Mr. Harry Himelblau, Room 813, 179 West Washington Street, Chicago, Ill., as their representative in the Chicago territory.

Clean producer gas has thoroughly demonstrated its efficiency and dependability in the Ford plant.

CHEMICAL EQUIPMENT ASSOCIATION BEGINS WORK.

The Chemical Equipment Association, comprising manufacturers of equipment essential to manufacture in the score or more of chemically controlled industry of the continent, has established national executive offices at 1328 Broadway, New York City.

It has begun active work through a national membership for the fostering of trade in chemical equipment, and for the improvement of practices in the production and distribution of such equipment, and in the performing of engineering services incidental thereto.

Not only does its activity signalize the adoption of trade association methods by the companies constituting the equipment base of the nationally vital chemical industries, but it represents a movement toward manufacturing and distributing co-operation in these same strategic points that has attracted the attention of Secretary of Commerce Hoover, who personally encouraged the organization of the Association and has elicited such comment as this from the New York Tribune, which said, in its issue of November 5, quoting an officer of the Chamber of Commerce of the United States:

"Such supply company organizations as the Railway Equipment Association, the Motor and Accessory Manufacturers' Association, the Association of Ice Cream Supply Men, the recently formed Chemical Equipment Association, and other groups representing the supply and equipment ends of leading industries, the members of which are manufacturers of miscellaneous commodities, but 'connected with a specific industry', for market expansion, educational work, publicity, research, credit protection, and prevention of trade abuses is one of the most interesting current trade association trends."

The Chemical Equipment Association was organized September 12, 1922, following preliminary activities of an organization committee of representatives of leading manufacturers.

The association has already established communication with nearly 200 of the large industrial associations of the country announcing itself as a source of information in chemical equipment supply matters, and has begun a regular bulletin service to members. The association is, further, arranging details of a permanent co-operation with the Department of Commerce in the collection and dissemination of vital trade information.

The Carbonization of Coal With Blue Gas and Producer Gas*

By W. REED MORRIS†

DURING the latter part of 1921 a blue gas and a producer gas plant were built at the works of the Seaboard By-Product Coke Company, Jersey City, N. J., for the purpose of increasing the send-out of city gas and to make possible a closer regulation of coke output with market demand.

The object of this paper is to present the results obtained from the blue gas and producer gas plant operations; to make comparisons of their over-all economy, and to consider the advantages and utility of each type of plant as adjuncts to a by-product coke plant. We present this data in the full realization of its especial importance at this time when the two-stage gasification of bituminous coal is receiving so much attention because of high costs of manufacturing gas and still further because of the condemnation of general use of raw coal. While the process used is not complete gasification, it is an advanced step in that direction. The use of producer gas or blue gas for oven heating disposes of the less saleable sizes of coke and practically doubles the amount of saleable coal gas per ton of coke to be sold.

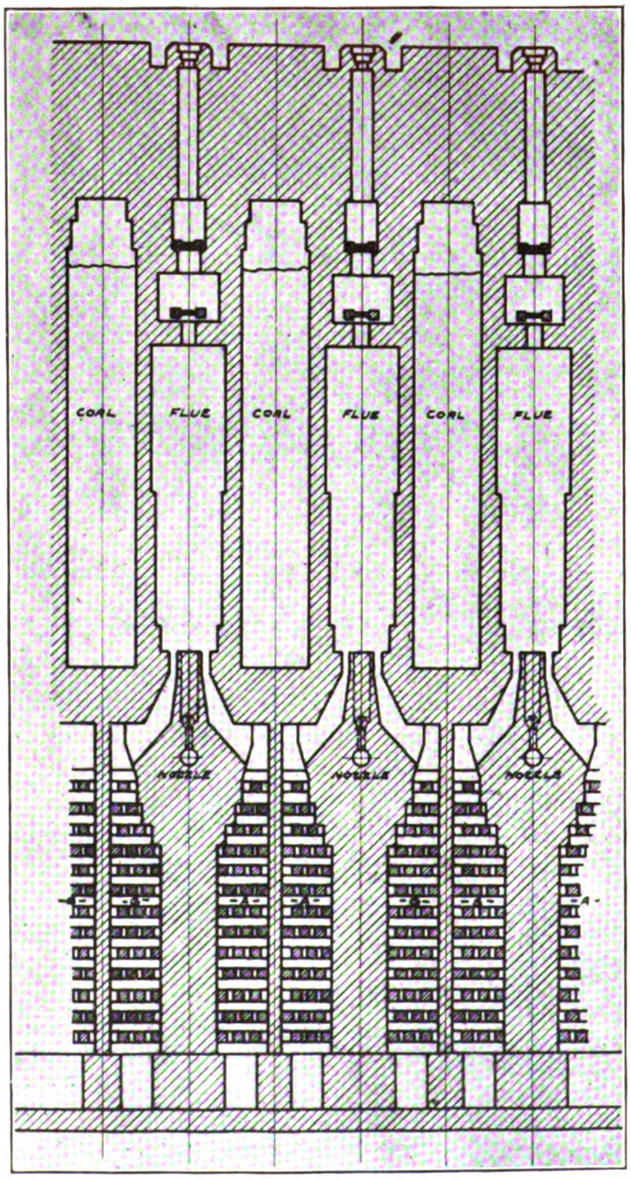

Fig. 1—Sections of Regenerators Showing Producer Gas and Air Inlets to Flues

As the Btu. requirements covering the sale of gas are lowered, the coke to be sold can be still further reduced by making additional blue gas or producer gas and mixing it with the coal gas, and it naturally follows that the lower the Btu. standard, the nearer the processes approach complete gasification.

The by-product plant at Seabord consists of 165 Kopper's type ovens built in three batteries of 55 ovens each. Two of these batteries are of the cross regenerative combination type, permitting the use of coal gas, blue gas or producer gas while the third battery can be heated only with coal gas or blue gas. Since the construction of the producer plant the two combination type batteries have been heated continuously with producer gas, and during last winter, when the coke market was still poor, blue gas was used to heat the third battery and for mixing with coal gas.

Both of these plants are thoroughly modern, being fully equipped with labor saving, and metering devices. Naturally, every effort was made to operate both in the best manner possible and whatever comparisons we present, are based on actual data and are entirely free from partiality for either manufacturing process.

BLUE GAS PLANT

Description of Plant.

The Blue Gas Plant was built by the Western Gas Construction Company and placed in operation in December, 1921. The plant includes three eleven foot generators (Fig. 3), each of which is connected in series with a combustion chamber and waste heat boiler. The combustion chamber corresponds in design and position to the carburetor of the ordinary carbureted blue gas, or water gas plant and is filled with checker brick. Differing from water gas practice both the "blow" gas and the "make gas" pass through the combustion chamber and in turn through the waste heat boiler. It might be noted here that blue gas practice does not require the maintenance of any given temperature in the combustion chamber, therefore, the blow on the generator is necessary only to the point of required heating of the generator fuel for the run and the object is to produce as little CO as possi-

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*Paper presented before the 1922 convenion of the American Gas Association.

†Assistant superintendent, Seaboard By-Product Coke Co.

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ble. In the future, if desired, superheaters may be installed without extensive alterations so that carbureted blue gas may be manufactured.

Fuel for the plant is stored in a 125 ton bin located (Fig. 2) at the end of the generator house and connected directly with the Coke Plant screening station by a 36 in. belt conveyor. From the bin the coke is discharged into a motor driven larry (Fig. 4) that runs on a track fixed to the roof trusses above the generators. On the larry is a 1 in. vibrating screen which removes the last traces of braize from the coke as it runs from the bin to the weight larry hopper, which is built as an integral part of a beam scale. The larry operator can weigh his load before and after charging the generator and determine the exact amount of fuel charged. The hopper has a capacity of five tons of coke, which is sufficient for two and sometimes three charges. The scale is checked frequently by means of standard weights by a representative of the scale company. From the larry a chute is lowered electrically to the charging hole and the generator charge made in about one minute.

The coke used averages about 7.5 per cent in ash and on occasions is a uniform egg size and at other times the regular water gas size, coming direct from the ovens. In the design of the coke handling equipment, every possible device is used to obtain the best screening and to minimize breakage. Just before entering the storage bin the coke passes over a five-row rotary grizzly screen with 2 in. spacings. A belt conveyor delivers the coke from the grizzly onto a shuttle conveyor directly over the bin, which is inclined with the slope facing the discharge end of the shuttle. The shuttle can be moved very close to the end of the sloping side and thus cut down the drop of the coke to a very few feet, almost totally eliminating breakage. As the bin fills up the shuttle is moved back filling the bin uniformly, and utilizing its utmost capacity.

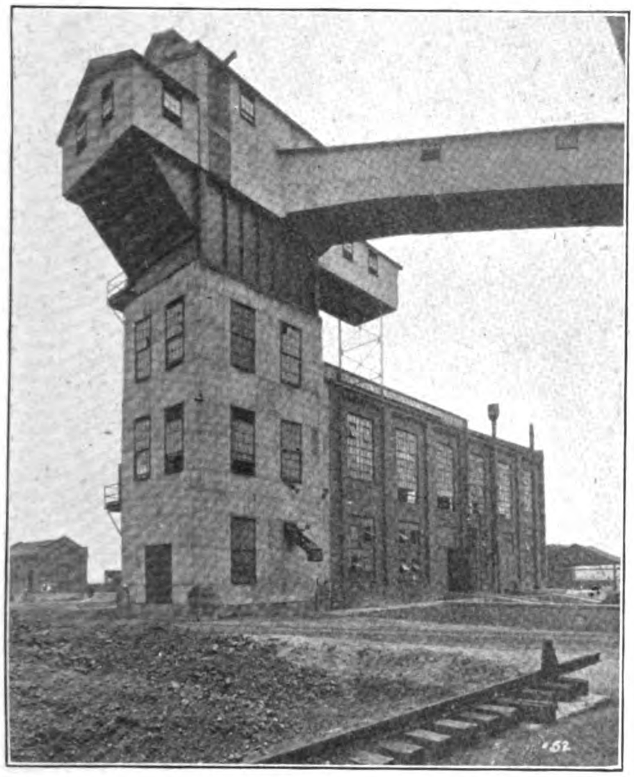

Fig. 2—Generator Building and Storage Bins

A novel feature of the plant is the Western Gas Construction Company's "Automatic Control" (Fig. 5); a very effective mechanism which maintains the cycle of operation with extreme accuracy, and makes the machines practically fool proof. Cycle, periods can be quickly and easily changed and a recording chart may be used to make a complete daily history of the operations.

The air fans are of the DeLavel type, with steam turbines operating against twelve pounds back pressure. The exhaust steam is used in the generator, which materially reduces the quantity of high pressure steam required.

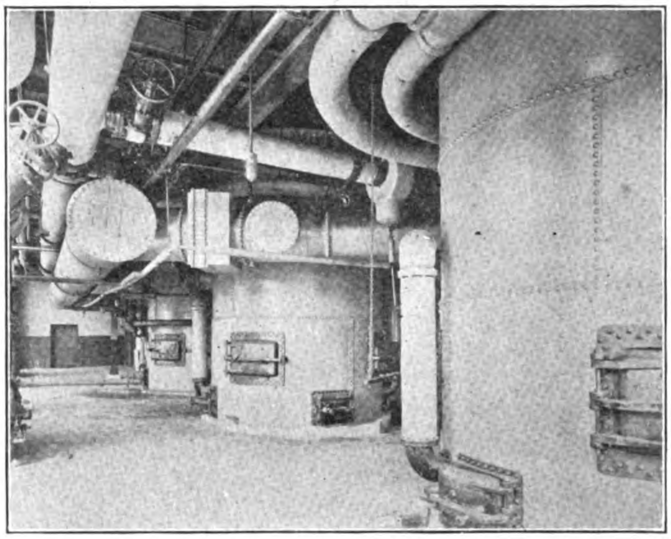

Fig. 3—Generators viewed from Clinker Floor

The gas made is burned under the ovens as required and the surplus is mixed with the oven gas in such proportions as to give the desired calorific value. The gas is measured before the ovens by means of a Venturi meter and before mixing with the oven gas by means of a Republic meter. The mixed gas is measured by displacement meters and analyzed for CO content. From long records and from concurrent analyses of oven gas the volume of CO due to the blue gas can be easily calculated, and is a good check on the accuracy of the gas meter. Other meters on air, steam and water used have permitted the accumulation of data which we feel is reasonably accurate and on which our calculations are based.

The labor required per eight hour shift is,

1 Foreman
1 Gasmaker
1 Boiler-tender
1 Engineer and pump-man
1 Laborer
1 Larry operator

In addition to the above two clinker gangs are employed, one working days and the other nights (eight hour shifts), each gang being composed of

1 Foreman
7 Clinker-men

BLUE GAS OPERATING DATA

GENERAL BLUE GAS OPERATIONS	JAN.	FEB.
No. of machines in use	3	2.7
Total coke used per day—tons	141	127
Dry coke per machine per day—tons	47	45
Gas made per day—M. cu. ft.	7250	7055
Gas made per ton dry coke—M. cu. ft.	51.8	58.8
Total Blue Gas Made—M. cu. ft.	224,740	197,555

Total Gas used at ovens—M. cu. ft.	127,982	151,760
Total Gas to surplus—M. cu. ft.	96,758	45,795
Gas made per run—M. cu. ft.	11.70	11.70
Fuel as charge/M. cu. ft.—lbs.	36.2	36.0
Dry Fuel/M. cu. ft.—lbs.	34.7	34.0
Carbon used/M. cu. ft.—lbs.	32.0	31.3
Pounds steam used/lb. dry coke	1.57	1.83
Pounds steam used/M. cu. ft. gas	54.3	62.1
Cu. ft. air used/lb. dry coke	64.3	66.8
Cu. ft. air used/M. cu. ft. gas	2,230	2,372
Av. Temperature outlet W.H.B./°F.	550	560
Cold gas efficiency	62.7	62.8

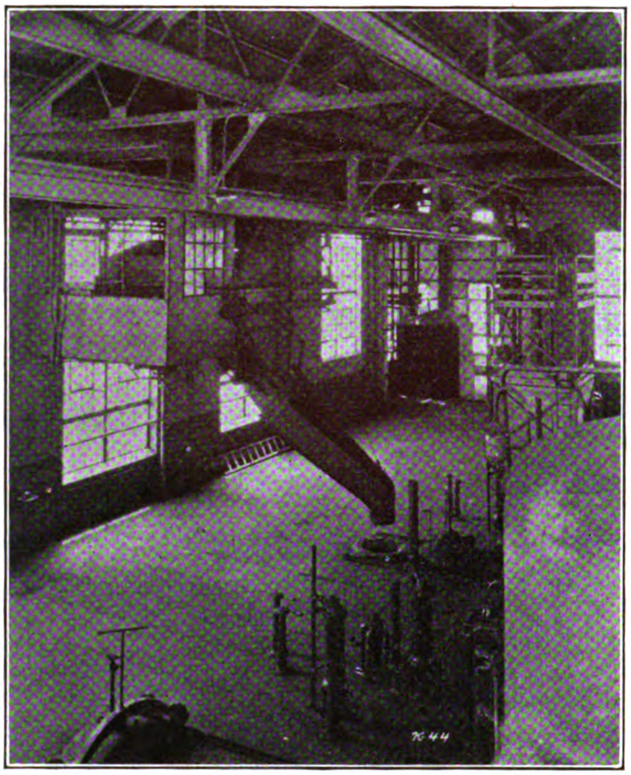

Fig. 4—Electric Larry in Charging Position

ANALYSIS:

Fuel	%V. M.	2.69	3.09
	%F. C.	89.80	88.51
	%Ash	7.51	8.40
	Btu./lb. dry coke	13,200	13,270
Gas	%CO_2	5.4	6.4
	O_2	0.7	0.7
	CO	37.0	36.1
	H_2	47.3	49.4
	CH_4	1.3	1.1
	N_2	8.3	6.3
	Btu./cu. ft. gr.	287	283

SPECIAL CARBONIZATION DATA:

Total coal, carbonized with blue gas—tons/day	513	683.2
%Underfiring (dry coke)	14.7	15.05
Pounds carbon in generator fuel/Ton coal carb.	258	264
Btu./lb. coal carbonized	1,155	1,193
Pounds dry coke/ton coal carbonized	294	301

BLUE GAS HEAT BALANCE

General Data—January, 1922

Gas Analyses	Blue Gas	Blast Gas to Waste Heat Boiler
CO_2	5.4	19.9
O_2	0.7	1.1
CO	37.0	....
H_2	47.3	....
CH_4	1.3	....
N_2	8.3	79.0

Analysis of Coke:

Moisture	4.2
Vol. M.	2.69
Fixed carbon	89.80
Ash	7.51
Steam input per M. of gas	51.9 lbs.
Air per M. of Gas	2,235 cu. ft.
Av. Temp. of gases entering Waste Heat Boiler	1,300/°F.
Temp. of gases leaving Waste Heat Boiler	550/°F.
Pressure steam in Waste Heat Boiler	150 lbs. sq. in.

HEAT BALANCE

Calculations based on 1000 cu. ft. blue gas, 60 °F.

Heat In			Btu.	%Btu. in coke
Item 1.	In coke burned		458,040	100
2.	In steam used		58,932	
3.	In blast			
			516,972	100
Heat Out.—Recovered.				
4.	Calorific value gas		287,000	62.7
5.	Steam made in W. H. B.			
	(a) 51.9 lbs. used under grate	58,932		
	(b) Heat in excess	5,768		1.3
	Total		64,700	

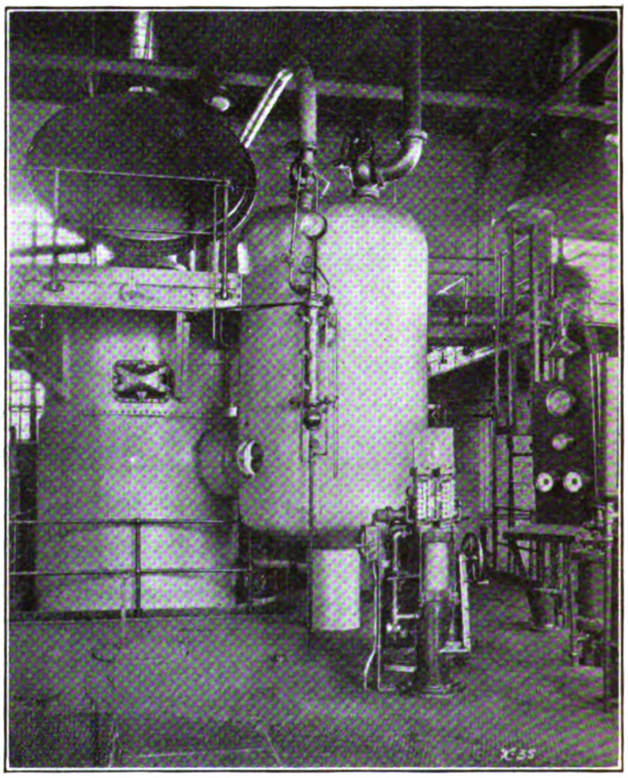

Fig. 5—Section of Operating Floor showing waste heat boiler, Mechanical Man, etc.

Heat Losses.

6.	Sensible heat blue gas and blast gas to condenser and stack	31,130	6.8
7.	Sensible heat undecomposed steam and moisture from coke to condenser	6,970	1.5
8.	Latent heat lost in undecomposed steam and coke moisture	29,550	6.4
9.	Loss in unburned carbon in ashes	59,000	12.9
10.	Radiation, boiler blow-down, and all other losses	38,622	8.4
	Total	516,972	100

PRELIMINARY CALCULATIONS

Basis of Calculations 1,000 Cu. Ft. of Blue Gas Based on Heat of Formation

Gas	Weight per M. cu. ft. gas	Heat of formation Btu. per lb.	Total Heat of Formation Btu. per M. cu.ft. gas
CO_2	6.23	3979.1	24800
CO	27.4	1869.2	51200
CH_4	.55	2435.6	1340
			77340

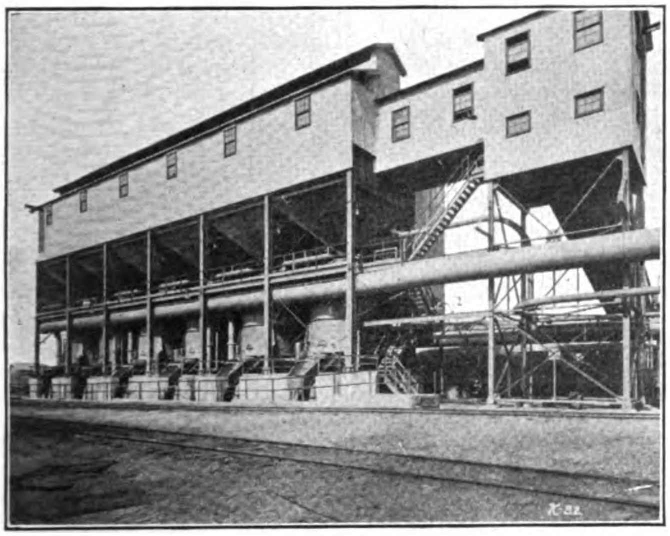

Fig. 6—Front of Producers Showing fuel bins, ash chutes

Weight of Water Decomposed

Hydrogen equivalent of Gas = Volume of hydrogen in gas + 2 volumes of CH_4

$= 473 + (2 \times 13) = 499$ cu. ft. hydrogen

1 cu. ft. hydrogen weighs .0053 lbs.

$499 \times .0053$ = weight hydrogen

$H_2 : H_2O = 2 : 18 = 499 \times .0053 : X$

$X = 23.85$ lbs. steam decomposed.

The heat of decomposition of steam is 5766 Btu. per lb.

$23.85 \times 5766 = 137{,}530$ Btu., to decompose steam
77,340 Btu. exothermic

60,190 Btu. must be supplied by blast

Calculations on sensible heat. Gas leaving caburetor at 1300°F. and W. H. Boiler at 550°F.

Heat Losses

Data on Mean Specific Heats Taken from Richards

CO_2	.19 +.00006	Btu. per lb. per °F.
O_2	.2104+.0000104	Btu. per lb. per °F.
CO	.2405+.0000119	Btu. per lb. per °F.
H_2	3.370 +.00017	Btu. per lb. per °F.
CH_4	0.38 +.00022	Btu. per lb. per °F.
N_2	.2405+.0000119	Btu. per lb. per °F.
Steam	.142 +.000103	Btu. per lb. per °F.

Air per M. of gas made, cu. ft.	2235
Steam per M. of gas made, lbs.	51.9
In coke as moisture	1.5
	53.4
Used	23.85
Undecomposed	29.55

Ratio Carbon Division

Carbon in blue gas	13.85 lbs./1000 cu. ft. Blue Gas
Carbon in blast gasses	14.10 lbs./1000 cu. ft. Blue Gas
Carbon lost to clinker heap	4.05 lbs./1000 cu. ft. Blue Gas
Total used	32.00 lbs./1000 cu. ft. Blue Gas

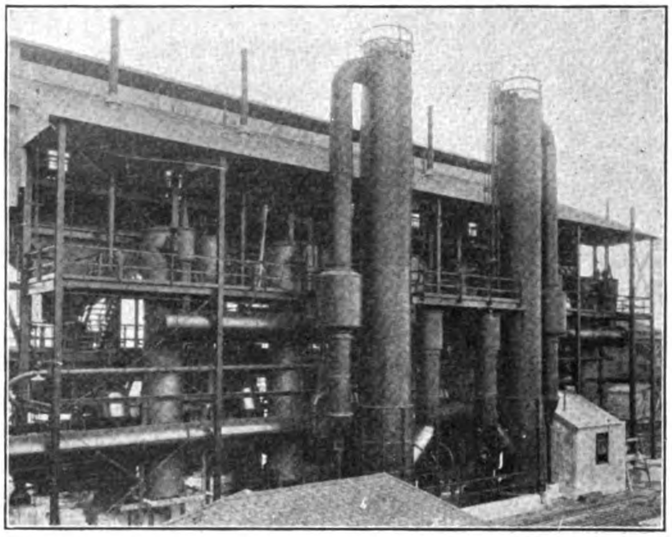

Fig. 7—Rear of producers showing waste heat boilers and coolers

Heat In

Item 11.

(1) Heat in coke used
$34.7 \times 13{,}200 = 458{,}040$ Btu.

(2) Heat in steam (1135.5 Btu./lb. = heat above 60° at 12 lb. gage)
$51.9 \times 1135.5 = 58{,}932$ Btu.

(3) Sensible heat in blast
Blast considered entering at 60°F., no sensible heat carried in.

Gas	Volume of Constituent in M. Cu. Ft.	Weight of 1 Cu. Ft. of Constituent	Weight of Constituent in M. Cu. Ft.	Sp. Heat per per lb./°F. 1300-500°F.	Sensible Heat per °F. per M. Cu. Ft.	Sp. Heat/lb. per °F. 550-60°F.	Sensible Heat per M. Cu. Ft.
Blue gas							
CO_2	54	.1164	6.23	.301	1.88	.2266	1.41
O_2	7	.08463	.59	.2296	.14	.2167	.13
CO	370	.07407	27.40	.2625	7.20	.2488	6.82
H_2	473	.0053	2.51	3.6845	9.25	3.473	8.72
CH_4	13	.04234	.55	.787	.44	.5142	.28
N_2	81	.07429	6.00	.2625	1.58	.2488	1.49
			Total		20.49		18.85
Blast Gas							
CO_2	199	.1164	23.2	.3010	6.97	.2266	5.27
O_2	11	.08463	.9	.2296	.21	.2167	.19
N_2	790	.07429	58.6	.2625	15.38	.2488	14.60
			Total		22.56		20.06
Steam			29.55	.6106	18.05	.4827	14.23

Heat Out

(4) Calorific value gas
287×1000=287,000
(5) Steam made in boiler
Gas enters at 1300°F.
Gas leaves at 550°F.
(a) Heat absorbed from blue gas
20.49×750=15,400 Btu.
(b) Undecomposed steam and coke moisture.
18.05×750=13,500 Btu.
(c) Blast Gases
2.235×22.56×750=37,800 Btu.

66,700 Btu.

Blow down and radiation losses estimated at 3% total.
Heat to raising steam=.97×66,700=64,700
Steam made —64,700=55.4 lbs. from 60°F.

1168.1

Heat Losses

(6) Sensible heat in blue gas and blast gas to condenser and stack.
(a) Blue gas
18.85×(550—60)=9230 Btu.
(b) Blast gas
2.235×20.06×(550—60) =21900 Btu.

31130 Btu.

(7) Sensible heat undecomposed steam and coke moisture.
14.23×(550—60)=6970 Btu.
(8) Latent heat in undecomposed steam and coke moisture.
29.55×1000 =29550 Btu.
(9) Lost in carbon in ashes
4.05×14544 =59000 Btu.
(10) All other losses by difference.

PRODUCER PLANT

Description of Producer Plant.

The producer gas used for heating of two batteries is supplied by a producer plant containing six Koppers' Kerperly Type producers. (See Figs. 6 and 7.) This plant and the construction of the Koppers' Kerperly Type producer were described in detail in the report of the Builders' Section of the Carbonization Committee of the A.G.A. for 1921.

The fuel used has been mainly the domestic stove and nut sizes. As separated at Seaboard, the stove size goes through a 2 in. and over a 1⅜ in. screen, while the nut size goes through a 1⅜ in. and over a ⅝ in. screen. These sizes have been used separately as well as mixed in all proportions. Any nut coke about which there is any question whatever as to its saleability because of braize is put in the producer bins. As the coke plant boiler house ordinarily uses the braize produced, there has been no occasion to use this size at the producer plant, since to do so would necessitate the purchase of coal for the steam plant.

Experimentally we have made extended tests on mixture of braize and nut. The screen test of a mixture tried was:

(Screen	Test	Nut Coke and Braize.)
On 1½"	0.0% through	100 %
On ½"	53.5% through	46.5%
On ⅛"	31.9% through	18.2%

Analysis of the Braize Mixture was:

% Moisture	12.0
% Vol. Matter	3.54
% F. C.	85.78
% Ash	10.68

Gas samples taken off the producer on braize mixture analyzed as follows:

	Test No. 1	Test No. 2
% CO_2	5.1	5.2
O_2	.1	.1
CO	28.7	28.3
H_2	13.0	12.3
CH_4	.3	.6
N_2	52.8	53.5
Btu.—cu. ft. gr.	138.9	138.2

It was possible to obtain a consumption per producer per day of an average of 35 tons of wet coke with a mixture of this character.

Frequent dust tests are made on the gas leaving the producer booster house and the dust content is found to run from two to four grains per 100 cu. ft. of gas. While this is small, the total content of 30,000,000 cu. ft. per day over a period of several months would run into the tons. Accordingly tests were made by drilling holes along the gas mains to the ovens, especially at corners or constrictions. No sign of dust accumulation was found, it being possible to strike metal with the test rod at every place. Thus it seems the velocity of the gas is great enough to prevent the very small dust content from settling in the mains.

The operating force at the producers per eight hour shift consist of:

Foreman	1
Chargers	2
Ash Handler	1
Boiler Tender	1
Exhauster Engineer	1
Total per shift	6
Total per day	18

This same quota could easily operate eight producers handlings 350 to 400 tons of coke per day, for their labor is of a simple, easy and routine nature. In fact, the force would actually be less for an automatic ash removal device would probably be used, which would cut ash handlers on at least two of the shifts.

For the time the producer plant operations were started, complete records of temperatures, pressures, quantities, (coke and gas) etc., have been kept. A typical record sheet showing the readings that are taken every two hours was used. The coke brought to the producer plant is weighed over a belt scale, the scale being tested monthly. It is also checked by unloading cars weighed on certified railroad track scales and running the coke over the belt scale. The coal carbonized is weighed on a beam scale, this scale being inspected daily and also checked once a month by an outside Engineer. Average gas and coke samples are taken daily and analyzed. The operating results are averaged daily and these daily figures are in turn averaged to give the monthly operating results. The month's results are shown as an average day's run, based on the entire month's figures. The results obtained from November, 1921, to May, 1922, are shown in the accompanying Tables I and II.

The month of April, 1922, was taken as a typical month, and a heat balance calculated for this month as follows:

HEAT BALANCE

Operating data for April, 1922, used as a basis for heat balance

Operating Results.

Fuel

Coal carbonized		1481.5	Net tons
Coke used		188.4	Net tons
Coke analysis	H_2O	13.6	
	V. M.	2.9	
	F. C.	88.33	
	Ash	8.77	
Btu./lb. dry		12744	
Btu./lb. as fired		11020	
% combustible in ashes from Producer		9.92	

TABLE I
AVERAGE OPERATING RESULTS

ITEM	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	7 Mos'. Average
Coal Carbonized—Wet Tons	1427.4	1510	1585	1620	1320	1481.5	1601	1506
Pounds Dry Fuel/Ton Coal	225	216	236	222	224	220	234	225
Pounds Carbon/Ton Coal	201	195	207	195	195	194	204	199
Daily Gas Make M. Cu. Ft.	25100	25600	28300	28000	23300	24900	29000	26310
Gas Analysis % CO_2	5.0	3.8	3.4	3.7	3.3	3.4	3.0	3.6
O_2	.3	.2	.1	.2	.2	.2	.1	.2
CO	27.4	29.4	30.2	29.8	30.4	30.7	30.7	29.8
H_2	11.1	10.2	10.4	10.1	9.7	9.7	9.5	10.1
CH_4	.4	.3	.3	.3	.3	.1	.2	.3
N_2	55.8	56.1	55.6	55.9	56.1	55.9	56.5	56.0
Gr. Btu.'s Cu. Ft.	128.5	131.4	134.6	132.3	132.8	131.9	132.3	131.9
Btu.'s/Lb. Coal Carb.	1132	1112	1200	1150	1170	1105	1200	1153
Cold Gas Efficiency %	76.9	76.5	79.2	79.8	80.5	79	79	78.7

TABLE II
HEAT DISTRIBUTION—SUMMARY

	ITEM	Btu.'s. on basis of average day's run	% Btu. in coke used
Heat in	In coke used at Producers	4,150,000,000	100
	Sensible heat air at 126°F	21,500,000	...
	Heat in steam entering with air	141,500,000	...
		4,313,000,000	
out re- and used	Calorific value gas	3,280,000,000	79.05
	High pressure steam made	314,000,000	7.57
		3,594,000,000	86.62
Heat covered	Heat fed back into produces as sensible heat in air and into steam obtained from L. P. Jacket	163,000,000	
Heat loss Distribution	Excess low pressure steam made	7,800,000	.19
	Unburned carbon in Producer ashes	45,700,000	1.10
	Unburned carbon in Producer ashes	45,700,000	1.10
	Unaccounted for producer losses—dust, radiation, etc.	49,200,000	1.18
	Boiler loss—blow down radiation, etc.	67,650,000	1.63
	Lost in scrubbers, cooling, water and radiation	385,650,000	9.28
		556,000,000	13.38
		4,313,000,000	100.00

Gas

Gas made per day (Dry at 60-30)............24900 M. cu. ft.

Gas analysis	
CO_2	3.4
O_2	.2
CO	30.7
H_2	9.7
CH_4	.1
N_2	55.9

Btu./cu. ft. (dry gas)............ 131.9

Operating Conditions

Temp. air blast °C........	52.1	126°F.
Temp. gas out producer °C.......	660	1220°F.
Temp. gas out W.H.B.°C..........	326	619°F.

Steam

Total water used in boilers per day..........435,103 lb.

Divided as follows:

Low pressure steam (5 lbs.)...............	150,282
High pressure steam (150 lbs.)..........	269,821
Boiler Feed Water in blow off Losses, etc..............	15,000
	435,103

Temperature boiler feed H_2O °C...... 104.3

Balance calculated on one days average run.

The summary gives the total heat distribution for the plant, the items being taken off the detailed distribution tables for each section of the Producer Plant which follow.

The calculations for each item on the detail tables are also given. The heat losses, etc., are all calculated from a base of 60° F.

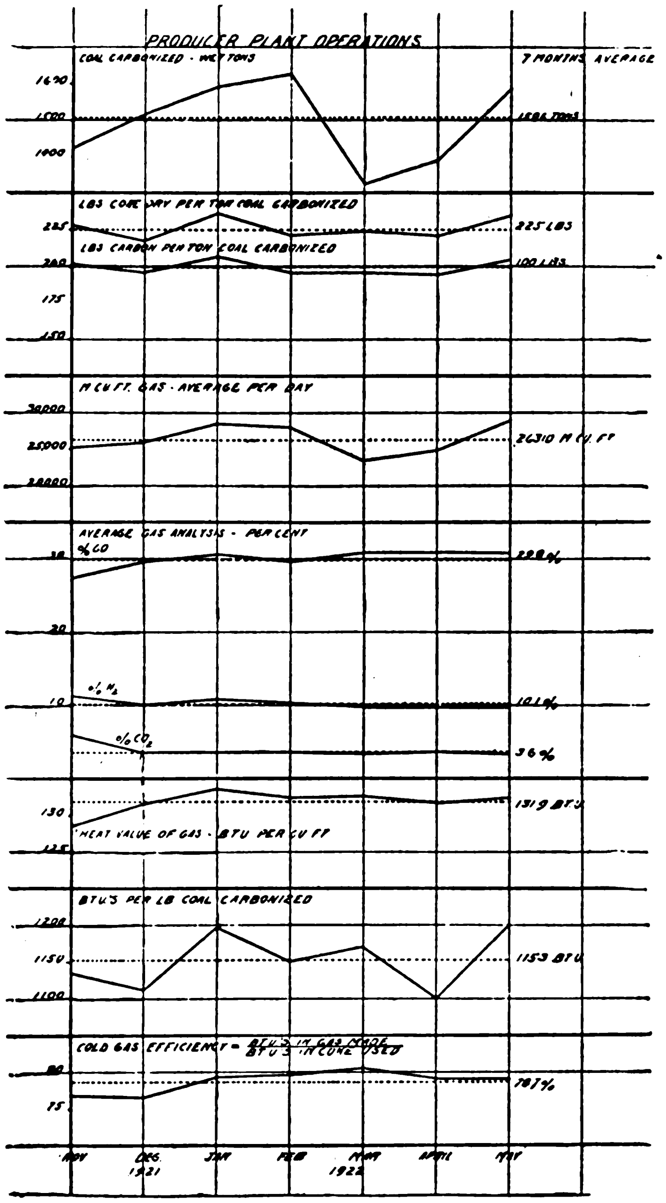

Fig. 8—Graph of producer operations

TABLE III

Detailed heat distribution in Producer

Heat into Producer			Btu./Day	%
Item 1.	In coke used		4,150,000,000	96.2
2.	Sensible heat air at 126°F.		21,500,000	.5
3.	Steam entering producer with air		141,500,000	3.3
	TOTAL		4,313,000,000	100.0
Heat out of Producer				
4.	Heat value of gas		3,280,000,000	76.0
5.	Sensible heat of gas		560,000,000	13.0
6.	Water (a) Moisture entering with coke	87,000,000		
	(b) Undecomposed steam	73,000,000		
	TOTAL		160,000,000	3.8
7.	Heat absorbed by low pressure jacket			
	(a) Low pressure steam made	170,800,000		
	(b) High pressure boiler feed water	47,300,000		
	TOTAL		218,100,000	5.1
8.	Unburned carbon in Producer ashes		45,700,000	1.0
	Unaccounted for losses by difference		49,200,000	1.1
	TOTAL		4,313,000,000	100

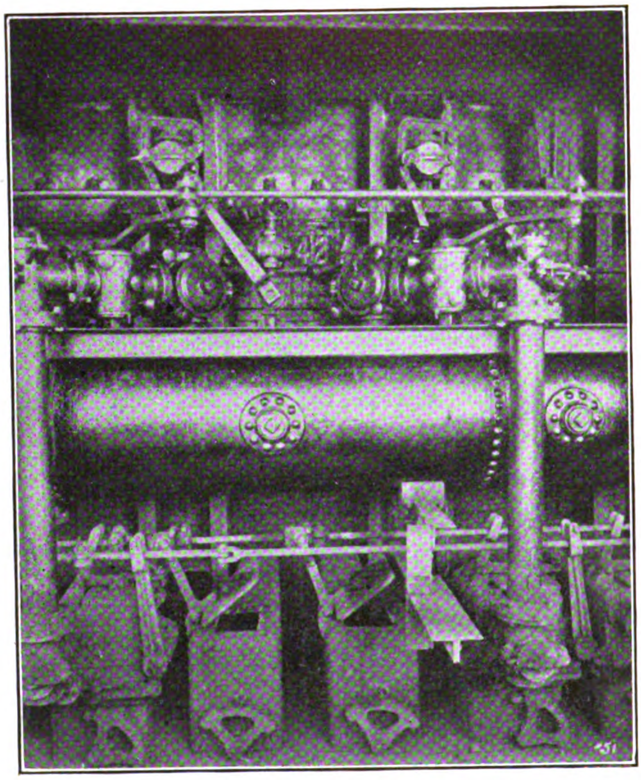

Fig. 9—Fuel main and connection to oven.

TABLE IV

Detailed heat distribution in waste heat boiler

Heat in		Btu./Day
Item 9.	Heat value of gas	3,280,000,000
10.	Sensible heat of gas entering	560,000,000
11.	Heat in water from coke and undecomposed steam	160,000,000
12.	Boiler feed water pre-heat	47,300,000
		4,047,300,000
Heat Out		
13.	Heat value of gas	3,280,000,000
14.	Sensible heat gas leaving	260,000,000
15.	Heat in water from coke and undecomposed steam	125,650,000
16.	Boiler blowdown loss	4,670,000
17.	High pressure steam made, from 60°F.	314,000,000
	Losses unaccounted for	62,980,000
		4,047,300,000

TABLE V

Detailed heat distribution in washer cooler

Heat in		Btu./Day
Item 18.	Heat value of gas	3,280,000,000
19.	Sensible heat of gas	260,000,000
20.	Heat in water from coke and undecomposed steam	125,650,000
	TOTAL	3,665,650,000
Heat Out		
21.	Heat value gas	3,280,000,000
22.	Lost to cooling water and radiation	385,650,000
	TOTAL	3,665,650,000

CALCULATIONS. Heat above 60°F. base

(a) The Producer

Heat in

1. In coke fired.
188.4×2000×11,020 = 4,150,000,000 Btu.
2. Sensible heat in air entering at 126°F.
Cu. ft. air used—$\frac{24,900.000\times.559}{.791}$ = 17,600.000

Btu. in 1 lb. dry air at 126°F.—30.40
Btu. in 1 lb. dry air at 60°F.—14.48
Btu. supplied by steam in
Heating air—/lb. 15.92
Btu. in with air 17,600,000×.07658×15.92 = 21,500,000Btu.

3. Steam entering producer with air.
Lbs. steam carrie by lb. air sat. at 126°F. = .0965.
Lbs. steam entering—17,600,000×.07658×.0965 = 130,000.
Heat entering—(above 60°) at 126°F.
130,000×(1116.2—28) = 141,500,000 Btu.
Heat per pound steam at 5 lb. gage 1157.7 Btu.
Heat per pound steam at 126°F. 1116.2
41.5
Heat given to air as sensible heat by steam expanded from 5 lbs. to partial pressure at 126°F.
TOTAL—130,000×41.5 = 5,400,000 Btu.

Steam In

Heat in steam at 5 lbs. = 1157.7
Heat in liquid at 126°F. = 93.9
Heat given to air by the condensation of steam, per lb. 1063.8
Steam condensed = $\frac{(21,500,000-5,400,000)}{1063.8}$ = 15,200

Excess Low Pressure Steam = 150,282—130,000—15,200 = 5,082 lbs.

Heat out of Producer

4. Heat value of Gas.
24,900,000×131.9 = 3,280,000,000 Btu.
5. Sensible Heat in Gas at 660°C.—(1220°F.)
Average sensible heat per cu. ft. of producer gas from 60°F. to 1220°F. = .0194
24,900,000×.0194×(1220) = 560,000,000 Btu.
6. Heat in water leaving producer.
This water comes from (a) moisture in Coke fired. (b) Undecomposed steam coming through fire. (c) The moisture entering in air and gas, which is neglected being small.
   (a) Moisture carried in with fuel and evaporated from 60°F.
   188.4×2000×.136×(1058 plus .552×(1220—60)
   = 87,000,000 Btu.
   (b) Undecomposed Steam.
   Ultimate analysis of Coke is assumed to have 9% H_2. Based on numerous tests.

Weight of H_2 in coke then is 188.4×2000×.009 = 3390 lbs.
Less weight Hydrogen in methane which is 263 "
3127 "
Weight H_2 in gas = 24,900,000×.097×.0053 = 12800 "
Less Hydrogen from Vol. M. in Coke 3127 "

Hydrogen from decomposition of steam 9673 "

Pounds, steam decomposed = 9673×9 =87,000

% Decomposition $\frac{87000}{136000}$ = 67%

Steam going through producer undecomposed = 130,000—87000 = 43.000

Heat at 126°F. 43000×(1162—28) 46,800,000 Btu.

Sensible heat 126°F. to 1220°F.

43000×.558×1094 = 26,200,000 "

Total carried out 73,000,000 "

Plus 87,000,000

160,000,000

7.

Heat absorbed in low pressure jacket.

This heat is found in low pressure steam made and in sensible heat in feed water to high pressure boiler.

(a) Low pressure steam at 5 lbs. gage

Heat at 5 lbs. per lb. steam = 1157.7 Btu.

Heat liquid entering at 54°F. = 22

1135.7

1135.7×150,282 = 170,800,000 Btu.

(b) hp. Boiler feed =

284,281×(220—54)— 47,300,000

Total heat absorbed in L.P. Jacket 218,100,000 Btu.

8.

Loss in unburned carbon.

188.4×2000×.864×.0877 = 31,600 lbs. total ash from

(1.00—.0992) producer.

188.4×2000×.864×.0877 = 28,500 lbs. in producer fuel

Combustible lost in ashes 3,100 lbs.

3,100×14,500 = 45,700,000 Btu. lost in ashes from producer.

Waste heat boiler

Heat In.

Items 9, 10, 11 and 12 are same as items 4, 5, 6 and 7 respectively.

Heat Out

13. Calorific value of gas same as items 4.
14. Sensible heat in Gas leaving at 326° (619°F.)
    Average specific heat gas from 60°F. to 619°F. is .01869 Btu./cu. ft.

TOTAL = 24,900,000×.01869×559 = 260,000,000 Btu.

15. Water—moisture from coke and undecomposed steam.
    (a) Moisture in coke
    54,200,000 plus 188.4×2000×.136×.490
    ×559 = 68,250,000 Btu.
    (b) 46,800,000 plus 43,000×.498×493 = 57,400,000
    Total 125,650,000
16. Boiler Blow Down.
    From recording chart average H_2O lost on Blow down was 15,000 lbs./day.
    Loss = 15,000×309.8 = 4,670,000 Btu.
17. High Pressure Steam made. (above 60°F.)
    269,821×1168.1 = 314,000,000 Btu.

COOLER

Heat In

Items 18, 19 and 20 same as items 13, 14 and 15 respectively.

Heat Out

21. Calorific value of gas going to ovens and used there same as item 4.
22. Absorbed by cooling water by difference from table is 385,650,000 Btu. which is lost to cooling water in washer scrubbers. This requires, with temperature differences obtained, about 27,000 gal. water per hr. This figure has been checked by Weir measurements on water leaving cooling sump.

Oven Operations.

A great deal has been said and written about the use of producer gas and blue gas in the heating of coke ovens. However, it has been so definitely proved that either of these gases may be used satisfactorily for oven heating that we shall not enter into this discussion other than to indicate a few of the salient points as demonstrated by our operations and to show the efficiency of burning these gases in the oven heating chambers.

Coal Gas, Blue Gas and Producer Gas are all handled with practically the same ease at the ovens and there is no difference in the labor requirements. The flexibility of the apparatus (Fig. 9) is such that blue gas or producer gas may be shut off the oven fuel mains and coal gas substituted on a few minutes notice.

The temperatures obtainable in the heating flues with either producer gas or blue gas are sufficiently high for the most rapid carbonization and the only limit is that of the fusibility of the brick lining used. There seems to exist a feeling among certain coke oven men that producer gas is not as good a heating agent as other gases. If producer gas is preheated to about 1700 deg. F. the theoretical flame temperature is almost that of oven gas and blue gas, using preheated air in all cases. For example, we found that these gases had theoretical flame temperatures as follows, the air in all cases being preheated, and producer gas alone preheated:

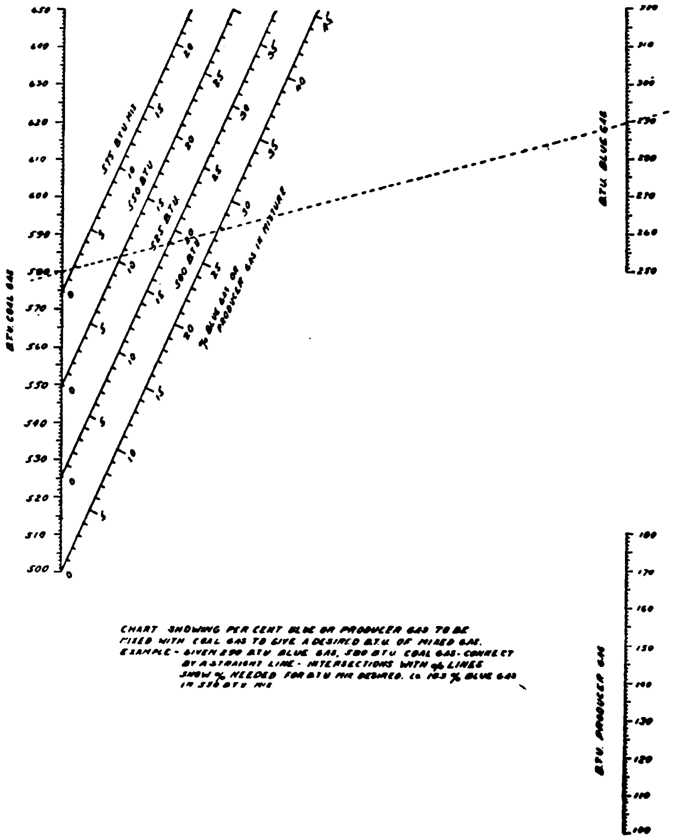

Fig. 10—Proportional gas mixing chart

	Flame Temp.
Oven gas	3738 deg. F.
Blue gas	3720 deg. F.
Producer gas	3645 deg. F.

Uniformity of temperature of the oven chamber from top to bottom with the resultant even temperature of the coke mass is greatly desired and with the particular type of ovens used at Seaboard there is no question that the best results are obtained with producer gas.

With regard to the number of Btu.'s required to carbonize a specified amount of coal, there is no discernable difference after the gas has been delivered at the ovens. The number of Btu.'s required in the form of coke used to make the fuel gas is a different question entirely and will be discussed under another heading of this article.

Following are typical CO_2 results obtained from a large number of samples taken from the heating flues,

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together with the theoretically perfect combustion obtainable from the producer and blue gas used:

		Waste Gas Analysis	Theoretical Analysis
Producer gas	CO_2	17.5 to 19.0%	20.5%
Blue gas	CO_2	17 to 18 %	20.1%

Our experience shows that regardless of the gas burned the combustion obtained is sufficiently perfect to satisfy the most particular.

We have collected a large amount of data of stack heat losses which show that they are practically the same with both gases. At least they are so nearly alike that the differences are within the limits of the measuring devices.

Summary.

We have endeavored throughout this discussion to present the facts as indicated by operating data which permits any one to draw his own conclusions as to the over all efficiency and utility of the use of either gas. But, for those who do not have the time to follow the details of the data presented, the following indicates to the future builder what he can expect in efficiency, over all economy, and flexibility from a blue gas or a producer gas plant.

(a) The overall or the gasification and combustion efficiency of producer gas is much greater than that of blue gas as shown by the following comparison:

	Producer Gas	Blue Gas
Pounds dry Fuel to carbonize a ton of coal	225	295
Pounds of Carbon to carbonize a ton of coal	199	261

In other words, only 76.3 per cent as much fuel is required with producer gas as blue gas to carbonize coal.

(b) Poorer and less saleable grades of coke can be more readily used in a producer plant.

(c) Producer operation requires much less labor per ton of fuel gasified.

Since the collection of the operating data given above, we have put through our six producers for a period of three weeks almost 300 tons of coke per day, or from 45 to 50 tons per producer per day without any appreciable difficulty and no addition of labor.

Carbonizing 50 tons per day per producer and 50 tons per day per blue gas generator the labor is:

Producer 0.51 man hours per ton gasified
Blue Gas 1.50 man hours per ton gasified

In the entire producer plant there is required no labor whatever of the particularly heavy or arduous type while no one questions the strenuous task of clinkering a water gas generator.

(d) Continuity of operation of a Producer Plant is such that the machines run for weeks and months at a time with no attention other than watching that the conditions set are regularly maintained. The possible mechanical derangements are a minimum. This must appeal particularly to the water gas man familiar as he is with the intermittent operation required with a water gas generator.

(e) Mixing of Blue Gas and Producer Gas with Coal Gas for the purpose of obtaining a specified Btu. can be done with equal ease. The amount of these gases which can be mixed to get any Btu. are shown on Chart, Fig. 10.

(f) The manufacturing cost of blue gas per million Btu's is fully 40 per cent greater than producer gas. This cost is based on the same value for generator fuel in each case, which is decidedly unfair to producer gas as it uses inferior, and therefore, cheaper grades of coke.

Conclusions.

As a part of a large by-product plant furnishing gas for city use a blue gas plant has advantages over a producer plant in times of coal shortages, caused by strikes or other contingencies beyond the control of the manufacturer. Also in a business depression, when the market for coke is poor and prices low, a blue gas plant is desirable because more blue gas than producer gas can be mixed with the coal gas, which also means that a greater percentage of coke can be turned into gas.

However, for anything like a steady operation a producer plant is a far better proposition.

1st. Because of its greater efficiency in changing heat units in the form of carbon to a combustible gas.

2nd. Because of the simplicity and ease of operation.

3rd. Because of the far lower manufacturing cost.

BOOK REVIEW

Sampling and Analysis of Coal, Coke and By-Products.—Methods of the chemists of the United States Steel Corporation. 184 pages. 18 illustrations. Published by the Carnegie Steel Company Bureau of Instruction, Pittsburgh, Pa. Price $3.00.

While this book appears as a second edition of the former pamphlet, it really is equivalent to an entirely new work. Not only was all the old material of the first pamphlet carefully re-edited and revised so as to bring all these methods up-to-date, but a great many methods and tests not covered by the former work are included in the new. The amount of this new material is indicated by the fact that the present book is more than double the size of the old.

The work naturally divides itself into two parts, namely, one covering the sampling and analysis of by-products. The first part embraces the sampling of coal and coke, physical tests on coal and coke, the proximate analysis of coal and coke, the analysis of coal and coke ash, the ultimate analysis of coal, determination of the calorific value of coal and coke, and the determination of coke and by-product yields from coal. The second part covers in detail the sampling and analysis of ammonia liquors and still waste; sulphuric acid, lime and saturator liquor; ammonium sulphate and ammonium chloride; coal tar and naphthalene; benzol, toluol, xyol, and solvent naptha; benzolated and debenzolated wash oils; and coke oven gas.

The new features, that is, those not touched upon in the older work embrace details for sampling by-product coke, physical testing of coke; determination of the different forms of sulphur in coal; fusibility of coal and coke ash; analysis of ammonium chloride; a method for calibrating thermometers; complete specifications for thermometers used for testing liquid by-products; many additional tests for benzol products and tar, such as cloud test, pour or cold tests, freezing point tests, specific heat, corrosion tests, etc.; wash tests for agitation products; and several tables covering gravities, weights and equivalents of sulphuric acid and aqua ammonia, and the conversion factors used in by-product laboratories.

Blast Furnace Operations During the Year

A Year of Extreme and Rapid Fluctuations—Very Little New Construction—World's Record Made by New Furnace at Warren, Ohio—Blast Furnace Now the Safest Place in a Steel Plant.

By J. A. MOHR*

THE general characteristics of the past year as shown by the entire steel industry, differed in no great degree, in the Blast Furnace Department. Nineteen twenty-two was a year of varying extremes.

One exception stands out, however, that is the by-product cement industry. This is mentioned because progress in cement is closely related to operation of the furnaces. Slag and power are essentials in cement production, and both are by-products of the blast furnace. The cement industry maintained full production during the year, due largely to the extensive road building program carred on in Pennsylvania and nearby states. At one period, 90 per cent of the entire daily output of a large cement plant was going into road building. What was true of this plant was relatively true of others.

In general the blast furnaces struggled through a difficult year. The coal strike disrupted the coke situation, resulting in frequent changes of furnace charges, and banking of many stacks for longer or shorter intervals.

The railroad strike left in its train embargoes, increasing numbers of bad equipment, dislocation of shipping schedules, and worst of all a dissatisfied mental attitude among workmen. No relief is yet in sight, and under present immigration restrictions, none can be for years. The European workmen, so sorely needed in periods of activity is prevented from entering this country, and conditions in Europe are still so chaotic that his living there is extremely precarious.

Mr. Mohr's long experience with large furnace units gives him an excellent perspective of the major tendencies shown by recent developments. He suggests the thought that changes are slow in blast furnaces for many evident reasons, but each year records refinements of detail, which taken in the aggregate combine to keep pace with the balanced whole.

Political misconceptions among war-torn countries prevent the return of real peace; the war is not over in the minds of many. When these issues are settled, the natural flow of men to opportunities will reappear, and the labor problem in America will be nearer a solution. Under such conditions very little progress was to be expected, and almost no new development. Many furnaces were idle a good part of the year, and much repair work was discontinued or postponed.

New Blast Furnace Completed.

One large new furnace was completed in the Pittsburgh-Cleveland district. Exceptional tonnages are being reported after a few months of operation. One day's record of over 850 tons with a monthly average of nearly 750 tons daily shows what is expected of furnace-men today with modern equipment. However, when excessive tonnages are reported, close scrutiny of charges is necessary for real comparisons. Melting scrap is not the same as reducing ore.

The tendency toward wider hearths, so conclusively developed in the western territory, is shown in this new record producer. The development of hearths has been gradual since the change from hard to soft ores. Tonnages from furnaces previous to 1906 had been relatively satisfactory. With the changing ores came a period of bad working furnaces with consequent low tonnages.

As individual furnaces were relined or rebuilt the hearths were conservatively enlarged. The bosh diameter has changed but slightly, remaining between 21 to 22 ft., but the slope distance between bosh-line and hearth has been progressively shortened with the slope angle increasing from 75 per cent to 83 per cent.

The most recent furnace built in 1922 has a hearth width of 20 ft. 9 in., compared to "D" furnace at Braddock built in 1922, which had a hearth diameter of 11 ft. 5 in. Where 16 ft. was considered wide in 1905, today 20 ft. and even 20 ft. 9 in. hearths are desired.

Fig. 1 shows a cross section of typical modern furnace recently rebuilt. The hearth diameter is 20 ft. 9 in.—the largest on record.

General Tendencies.

Electric operation of top and bell has grown in favor; but the surrounding conditions may limit this selection to newly built furnaces. Some form of distributor is universally desired, although progress in the installation is necessarily slow and costly.

Both the rotary top (such as the McKee type) and the stationary top find favor with the operators in northern plants; southern operators still prefer distributors of the Brower type.

The great value of proper distribution of the materials in the furnace charge has received constantly increasing attention both from investigators and operators, and we are many steps nearer the solution of this highly important factor in uniform furnace operation.

Refractories have improved, due perhaps to better workmanship, now that war time influences have waned. A new silica brick, machine made, closely resembling the best hand made brick, of excellent porous structure has appeared. This may reduce silica brick costs, somewhat, but costs are problematical these days.

The tendency toward small checker openings seems to have reversed itself. Instead of 2½-in. the prefer-

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Superintendent Blast Furnaces Carnegie Steel Company, Carrie Furnaces, Rankin, Pa.

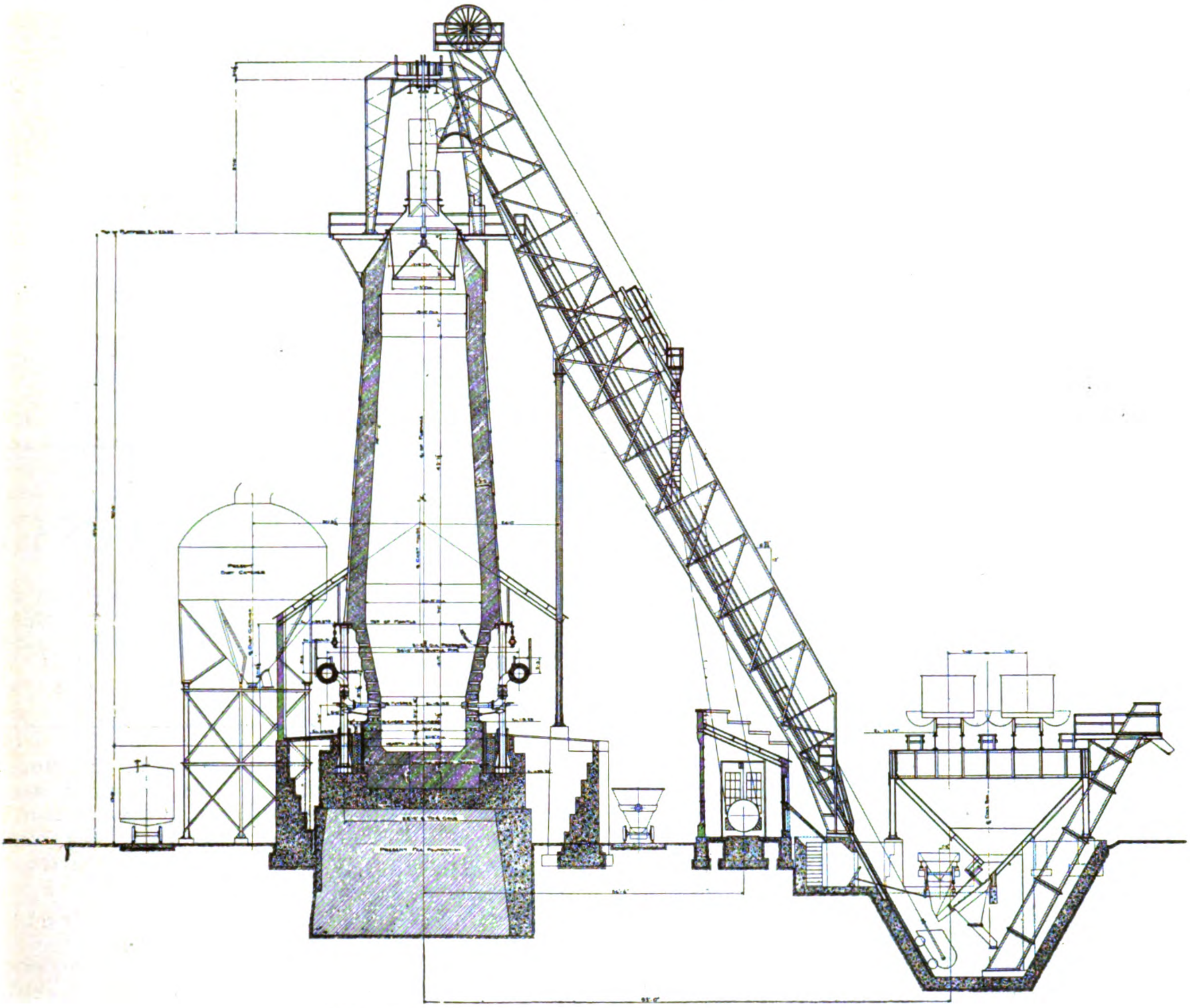

Fig. 1—Cross-section of typical modern blast furnace.

ence seems now toward 3½ in. or even 4-in. opening. This is of course dependent upon the gas characteristics and the method of cleaning. Clean gas is now demanded, but the extent of cleaning and the method is still open to discussion. Dry cleaning by one method or another seems preferable. The arguments pro and con need no discussion, they would fill a book. Electric precipitation, so successful in cement kiln practice, bids fair to be ultimately developed and simplified. Various centrifugal separators occupy their field, while in Europe this principle, has been amplified into intense precipitation toward the periphery, by means of high speed blowers or fans inducing higher velocities. Very little information is yet available, however, but the development will be watched with great interest.

One thing is certain:

The blast furnace is now the power house of the steel mills, as it should be, and every effort is being concentrated upon the recovery of every available Btu. contained in blast furnace gas.

Heat Wastes Being Corrected.

In the early days of huge cross-compound blowers, reciprocating pumps, steam operated ore-bins, hoists, etc., there was an abundance of surplus gas, which frequently required bleeder openings to relieve excessive pressures. Little thought was given to the wastage of this gas, or of the steam produced incidentally. When the steam dropped, as it frequently did, especially on wintry days when many ore-cars had to be unloaded, no one was greatly concerned at the hand-firing of coal, on badly designed flat grates; coal was cheap, labor was willing to work hard, and coke-dust was a nuisance, nothing more.

Today a "heat balance" is a study to be applied. The question, whether the boilers consume some 52 per cent of all the gas is very important, and every effort is made to increase this percentage because this means additional power for mills for cement plants, and various motor-driven operations far removed from the blast furnace itself. Some times we wonder whether the blast furnace is supposed to make iron or power. For like reasons, the percentage of gas going to the stoves is carefully watched and recorded, and persistent efforts are being made to reduce this percentage to its lowest denominator, consistent with best furnace operation.

Recent Installations.

Coke dust now finds its outlet in specially designed steam generating units, where its available power can best be recovered, and the costs of transportation and dumping at distant points eliminated.

Where coal is fired, and it is often desirable to burn coal in emergencies, it is fired with a definite idea of the results to be obtained, and under more ideal methods.

Foreign Competition.

Much talk is prevalent of foreign competition. That might have been serious shortly after the war when scrap was cheap and available, and living costs in Europe had not yet mounted, but today, it is difficult to conceive of German competition under present economic conditions there.

French and Belgian furnaces are in blast, but French competition has never been serious.

The safety investigations throughout the steel industry have left a strong impression upon the Blast Furnace Department. In years gone by, work around furnaces was considered extremely hazardous. The prevalence of a noxious gas usually in combustible mixtures, the handling of enormous tonnages by cars, cranes and hoists, the flows of molten metal in close proximity to accumulations of water, the operation of huge pieces of machinery involving unusual heights, all contributed to the possibility of danger.

Today the records indicate that the Blast Furnace is the safest place in the entire steel plant.

A recent departure in this direction has been the change to tap hole burning using Oxy-hydrogen torches in place of the former practice of manual opening with long steel poking bars. Careful investigations along other similar points of hazard have shown excellent results.

Pioneer Furnace and Its Worthy Successor

"Brooke Blast Furnace" the Pioneer West of the Allegheny Mountains—The Products of This Primitive Iron Smelter Helped Win the Civil War—Near Site of World's Largest Modern Furnace.

By R. C. HEASLETT*

"HISTORY repeats itself" is a time honored expression and may be applied to a great diversity of circumstances. However, its application has seemingly never been more fitting than the instance that has put Weirton, West Virginia, on the map. The blast furnace of the Weirton Steel Company, a furnace capable of producing more pig iron per day than any other furnace in the world was built on a site almost a stone's throw from where the first iron furnace west of the Allegheny Mountains was built more than a century and a quarter ago.

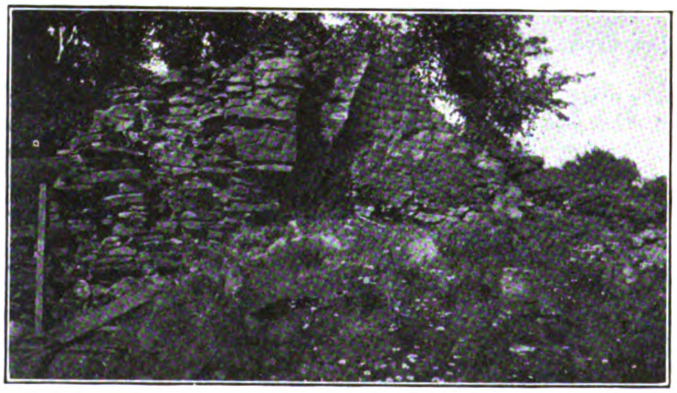

Fig. 1—General view of remains of ancient furnace from front.

"The Blast Furnace and Steel Plant," of October 20, 1920, contained a very brief article mentioning this furnace as "the oldest industrial land mark west of the Alleghenies." There was also a statement that its builder and first operator was a man by name of Grant. This was an error easily explained, since the original records used the words Peter Tarr, grant, which was interpreted to mean that a man by name of Grant was the original owner, when in fact it simply showed that the furnace was on a plot of ground which was a part of the "land grant," of Peter Tarr.

The writer having lived in the vicinity of Weirton for a period of years has often visited the scene of this early iron industry and has, therefore, been in a favorable position to get first hand facts and information as to its history. It is indeed a most interesting picturesque and fascinating story, with its colored settings of hills, valleys, waterfalls, virgin forests and native inhabitants.

The First Blast Furnace West of the Alleghenies.

The Indian wars were practically over, although there were still many red-skins roaming over the hills of the Panhandle, when in the year 1790 Peter Tarr, of Prussian decent, came to Pennsylvania, and with some other pioneers wended his way over the mountains to the Ohio Valley. On the banks of King's Creek which flows into the Ohio River just to the north of Weirton, the emigrants found a peaceful settlement and prepared to make their homes and establish a means of livelihood, and although most of the settlers of that time considered farming and stock raising the natural vocation, still others followed the arts of tanning, lumbering or brick making. However, it remained for Peter Tarr to realize a dream and be the first iron master west of the Alleghenies. Here on the banks of the creek he, with the help of other settlers erected a furnace for smelting iron ore. It may truly be called a blast furnace, since the draft was produced by bellows, which in turn derived their motive power from a race and waterfall adajacent to the creek.

The furnace as it stands today is only an historical relic as it remains only partly intact. However, there is quite enough to gain a good idea of the nature of its structure, size and general proportions. The remaining portions would indicate that it had an inside diameter ranging possibly from 10 to 12 feet, while the outside diameter must have been close to 25 feet. The height is a matter of conjecture, as the upper portion has evidently fallen away or has been torn down. It would seem, however, that it might have been something over 20 feet high, perhaps much higher. As can be seen from the accompanying illustrations the front of the structure has fallen away leaving only the rear half. The refractory was well cemented together and still remains intact. It is composed of a high grade sand-stone and seems to have withstood the heat without much deterioration. Its face is still covered with an ancient coat of one fluid slag, which even now forms a glossy covering of variable coloring. Fragments of the slag which are strewn around the base of the relic resemble to a marked degree the slag of a modern blast furnace, and analysis shows it to compare quite favorably.

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*Chief Chemist, Wheeling Mold & Foundry Co., Wheeling, W. Va.

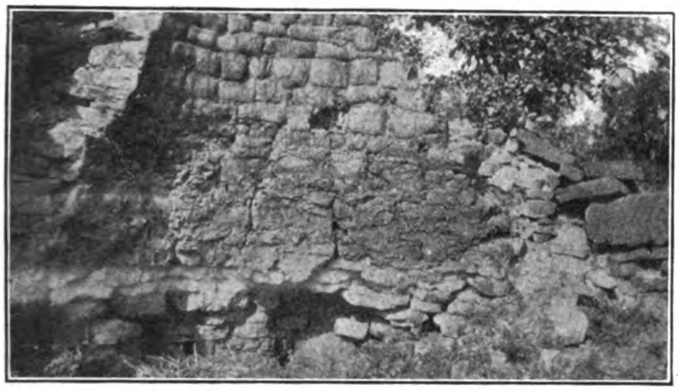

Fig. 2—The melting zone is easily distinguishable but the tuyers have been entirely obliterated.

Surrounding the approximate 15-in. wall of inner refractory is a massive wall of five or six feet of secondary insulation. This is made up of successive layers of flat sand-stones, gathered from the vicinity and held together with mud. The metal and slag were undoubtedly drawn from the front, while at the rear still remains what was evidently a runway to the charging platform. The topography of the back-ground was utilized for this runway, as the space between the furnace and hill at the rear was quite easily filled in, and formed a natural bridge. Over the bridge was wheeled or carried the many tons of raw materials used in making the finished iron. These raw products consisted of a fair grade of iron ore quarried from the adjacent hills and carried by hand or on mules to the smelting furnace. This ore, although not seemingly found in large quantities and of no high grade purity, was evidently applicable to their methods and sufficient for their needs. The limestone, was and still exists in abundance in this locality and, therefore, was easily procured. The fuel and reducing agent was not coke such as is used today, as at that time coke and coal were not extensively used, but charcoal. This was produced for the refiners by burning the wood from the trees of the forest which were on every side; and converting the wood into charcoal was then relatively quite as important in the industrial line as the coke business is today.

There seems to have been a foundry connected with the furnace, and the first output of about two or three tons a day was confined to the needs of peace. Iron grates and irons for the fireside, kettles, skillets, and heavy utensils for the kitchen, plowshares, cart and wagon parts and farming implements, for the agricultural trade, all played an important part in the needs of the early folk. These articles found a ready market not only for the settlers of the direct vicinity, but for the surrounding country as far north as the great lakes, south as Wheeling, W. Va., and east as Pittsburgh, Pa.

Products Important for War Purposes.

But by far the most interesting products of this furnace were materials which was used in the war of 1812 and whose importance can hardly be estimated.

Commodore Perry was preparing to construct a fleet to attack the British on Lake Erie. He had eight small sea worthy vessels, but realized this was not sufficient to match forces with his enemy. The British also knew of Perry's limited number of ships, and thought there was no prospect of his getting more. However, the Commodore was a man of action so he sent his men into the forests along the lake to hew out timbers for two more much heavier boats. Carpenters, canvas and cordage were rushed from New York and Philadelphia. Iron castings and forgings to help in their construction would also be necessary, so he turned to the nearest available source of supply—namely, the foundry and forge on King's Creek, West Virginia. The work of making the iron castings was pushed with all speed possible and as soon as completed, were carried by mule packs over the Indian trails to Presque Isle, now the city of Erie, Pa. Commodore Perry also needed more ammunition, especially cannon balls, and again he turned to the King's Creek furnace, so perhaps the most noteworthy product of this antique foundry was the solid cast iron shot that, according to history, was poured direct from the furnace into the molds, thus duplicating in a way some of our modern

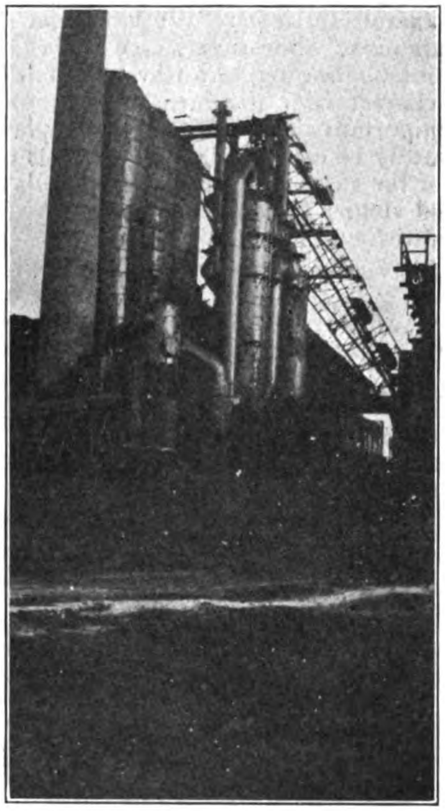

Fig. 3—The modern blast furnace of Weirton Steel Company.

methods of production. These cannon balls were also transported to Presque Island by placing them in paniers carried on the backs of mules.

"We Have Met the Enemy and They Are Ours."

The Commodore now made ready for the naval attack which was an outstanding event in American history. The fleet was arranged in battle formation and to the utmost astonishment of the British the fleet of Perry which was known a short time before to consist of only eight vessels, had miraculously grown to ten. The battle soon waged furiously and in a short time Perry's famous slogan "Don't give up the ship" resounded across the waters of the lake, and stirred the Americans to greater action.

As a result, he a little later sent the following message to General Harrison: "We have met the enemy and they are ours," a message which made Commodore Perry an outstanding figure o fthe war of 1812, and an historical character for all time. As mentioned before, just how important a part the old furnace played in this war can hardly be estimated, however, it is certain the castings for the extra ships and cannon balls for all the fleet spelled victory to the Americans in this battle and established their prowess on Lake Erie

This old relic stands as a land mark in early history supplying the country's needs in time of distress, and as the builder stands forth as a patriotic pioneer through whose efforts the foundation of our United States became more firmly established, so stands the colossial blast furnace of the Weirton Steel Company, a feat of modern engineering and fitting successor to the ancient structure; to keep and preserve the ideals that our country holds dear As the old furnace helped bring victory to our forefathers, so this great furnace in the recent world war made enormous quantities of iron used in producing war materials These materials helped provide for our armies in the field—fighting to maintain the liberty acquired, through the battles of more than a century ago. The former was the oldest munition parent worthy of its great successor. The men of that day did their work well and it reads like 24 tons a week as compared against a record of 23,000 tons by which Weirton now holds the world's record.

From a point of view of early industrial activities in the Panhandle, it is also interesting to note that in the year 1800, Wm. Griffith erected an iron forge on his farm on Kings' Creek about one mile from where the historical iron furnace stood. This was operated for a number of years but there seems to be no evidences remaining to define the exact location. Malleable iron for this forge was secured from an ancient furnace on the Cheat River, West Virginia, and was conveyed by boats up the Cheat River to the Ohio River, thence to King's Creek via the Ohio.

From the landing at the mouth of the creek it was loaded in wagons and hauled up the creek to the forge. It is also recorded that "a very good grade of iron from the King's Creek furnace, was used by this forge."

Thus knowing the early start West Virginia secured in the refining and fabrication of iron, it is not surprising that today it stands with the front rank states in the manufacture of iron and steel products.

LITTLE LUXEMBOURG'S BIG STEEL INDUSTRY

In 1921 the Grand Duchy of Luxembough produced iron and steel products to the value of $54,043,456 on the comparatively low valuations of that year, the products of its iron mines and iron and steel plants in 1920 having reached the large total value of $89,120,260. One of the most interesting features of the situation is that in the first nine months of 1922 the Grand Duchy has shipped to the United States, directly, iron and steel to the value of $537,105 in addition to the large quantity of such products shipped to the United States by way of Belgium and Great Britain.

Immediately previous to the World War Luxembourg was the fifth largest iron producing country of the world, but the war led to a sharp decline in this output while political changes effected by the treaty of Versailles entailed a complete reorganization of the industry by the transfer of ownership of many of its plants, the regrouping of allied, and the adjustment of opposing interests, and by bringing about conditions which have forced the industry to seek new markets and adjust its business to entirely new conditions.

The Grand Duchy has not yet reached its pre-war production either in mines or mills but the fact that its furnaces and steel mills have increased their output in 1921 over 1920 by nearly 50 per cent and that the output in 1922 shows a much larger increase indicates that the industry has regained its vitality and that its position in the iron and steel world merits the careful attention of all possible competitors, says Consul General George E. Anderson, Rotterdam, in a report to the Department of Commerce. This impression is deepened by the fact that Luxumbourg is now exporting its ferrous products all over the world and is rapidly establishing the output of its factories in countries where its products have never before been known. On an average something like nine-tenths of the iron and steel products of Luxembourg are exported. Two of the principal companies have formed a selling company to which they have conceded a monopoly of the sale of their products while a third company is partly owned by the sales company. This organization in the past few months has completed agency arrangements over nearly the whole of the principal iron and steel consuming countries of the world. Sales to Germany and Austria have declined, but the purchases of Belgium, Holland, and Great Britain have increased very materially. The chief development of the trade is through connections recently made in Brazil and the Argentine, the East Indies, Japan and China.

Market for Iron and Steel in Brazil.

The American position is very strong in the Brazilian market for sheets, says Commercial Attache Schurz, and it is good in the bar and wire market, although the demand is weak at present. Competition from Belgium and Germany is keen, and England is becoming more and more a factor in the trade. Belgian and German manufacturers are very strong in the rail market.

Steel Stocks in Shanghai Being Reduced.

Shanghai steel import business continues sluggish, according to a report to the Department of Commerce from Trade Commissioner L. W. Hoyt. The local speeding up in Chinese domestic trade, however, is an encouraging feature of the situation. Shanghai steel stocks have been gradually reducing themselves through a "hand to mouth" trade and while there has not been any change in the number of inquiries for steel products, the technical position of the Shanghai market is considerably improved.

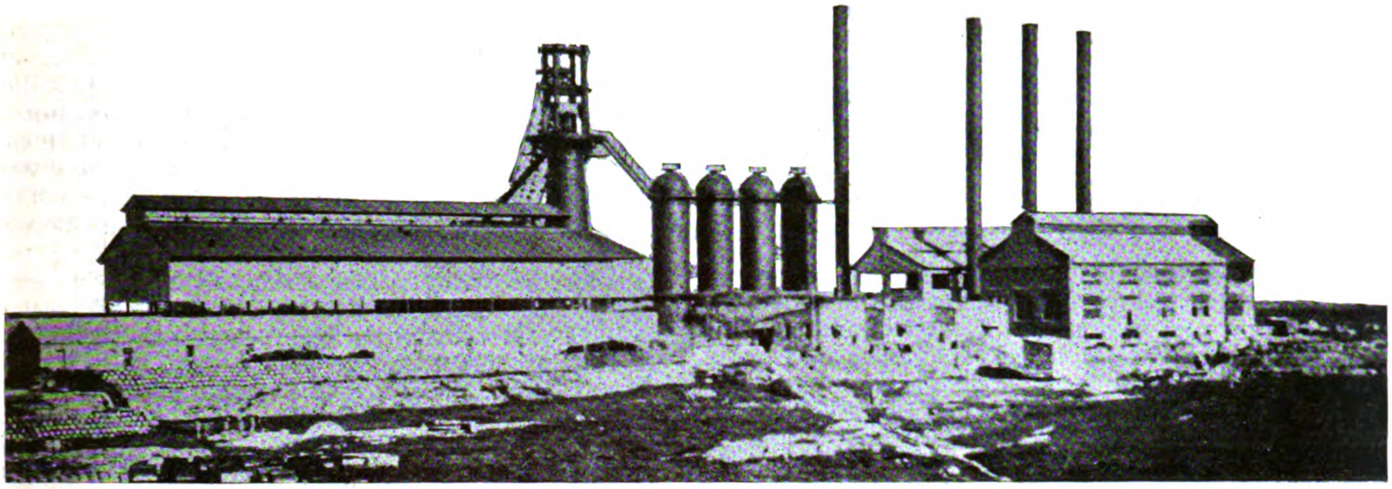

Fig. A—General view of the first modern blast furnace plant in Northern China, indicating clearly the arrangement of the various units.

First Modern Blast Furnace in North China

The Lungyen Mining Administration Completes 250-Ton Furnace Within Nine Miles of Pekin—Built Largely of American Equipment by American Engineers, But by Chinese Labor.

By PAUL F. KOHLHAAS*

WITHIN a short time the Lungyen Mining Administration will place in operation its new 250-ton blast furnace plant, and with this occurrence the world will see the blending of Oriental and modern methods to an unusual degree. The plant, now nearly completed, is located within a dozen miles of Peking, and less than 90 miles from the famous Great Wall of China, and the tombs of the emperors of the Ming dynasty.

This installation has a particular significance in the light of recent developments regarding China's political autonomy and the long hoped for industrial awakening resulting therefrom. The world is watching with interest the next stage of affairs and it is therefore felt that the description of a unit which will undoubtedly show some influence in the working out of China's future would be of interest to all, and to the engineering profession in particular.

It is not the intention at this time to go into a discussion of the raw material resources of China generally relative to the iron and steel industry, nor to enlarge upon the reasons for their lack of development in past years. Suffice it to say that China has the material resources capable of supporting a large industry of this nature, that the Chinese realize this, and with the new trend of their affairs we may feel that the industry is going to advance from the quiescent state it has occupied thus far to one of ever increasing activity and importance.

South China Now the Iron Center.

At present South China is the center of China's iron and steel industrialism, Hankow being the "hub" of activity, and in fact, being frequently referred to as the "Chicago of the East." In this vicinity are located the large iron making units, and a few steel plants and engineering works. These include the plant of the Hanyang Iron Works, with two comparatively modern blast furnaces and a steel plant; the Tayeh Iron and Steel Works, with two blast furnaces; and the Yangtze Engineering Works with one 100-ton per day blast furnace, and an engineering works.

Until the installation of the new Lungyen furnace, North China was without any units of the iron or steel industry, excepting some small hand forges, dating back to ancient times and handed down from father to son for generations. The amounts of iron produced by this method are of necessity small, possibly several tons each per week, but of a very good grade. They naturally have only local influence. The plant now nearing completion, therefore, stands alone in an immense territory thus far principally devoted to agricultural pursuits, and it does not require a vivid stretch of the imagination to foresee that it is bound to show some influence in future developments in that region. A better idea of the size of this territory may be given by stating that it is practically equivalent in area to the entire portion of the United States east of the Mississippi river.

Backed by the Government.

The Lungyen Mining Administration was organized in 1918 by the merger of several groups controlling iron ore poperties, for the purpose of acquiring mineral concessions and the manufacture of iron and steel. The government of China, as well as prominent individuals, subscribed to the proposition. After considerable investigation of iron ore and coal properties the decision was finally reached to proceed with the first unit, and the firm of Perin & Marshall of New York City was engaged as consulting engineers for the design of the plant.

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*Brooklyn, N. Y.

The site chosen is at Shichinshan, 11 miles west of Peking, with the Yungting river on one side and the Peking-Mentoukou railroad on the other. This location is quite favorable for receiving raw materials and for the disposal of the product. It is sufficient in size for the establishment of a very large plant.

Raw Materials Accessible.

Iron ore will be secured from the mines at Hsuanhwa in the Kalgan region, a distance of about 110 miles north of the plant site. The ore in this field averages from 45 to 55 per cent iron content. While a large part of it is high in silica, there are also low silica depostis available. Considerable work has been done in opening up these deposits. A large tonnage of this ore was shipped to the Hangyang Works for a trial smelting, with very successful results.

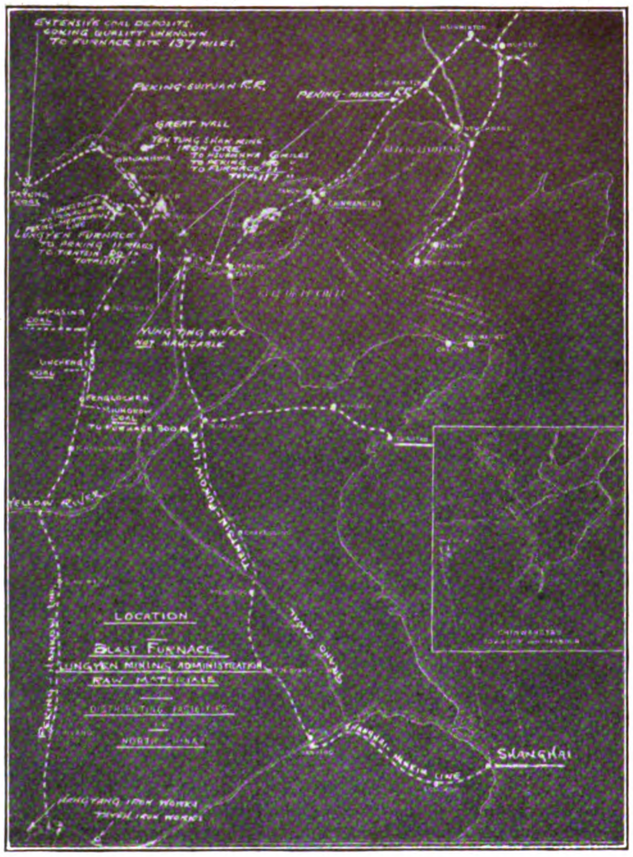
EXTENSIVE COAL DEPOSITS. COKING QUALITY UNKNOWN TO FURNACE SITE 137 MILES.
PEKING-SUIYUAN R.R.
PEKING-MUKDEN R.R.
GREAT WALL
YEN TUNG SHAN MINE IRON ORE TO HSUANHWA TO PEKING TO FURNACE TOTAL 117
TATUNG COAL
LUNGYEN FURNACE TO PEKING 11 MILES TO TIENTSIN TOTAL 101
YUNG TING RIVER NOT NAVIGABLE
COAL
FENGLOCHEN
COAL TO FURNACE 300 M
YELLOW RIVER
SHANGHAI
LOCATION
BLAST FURNACE
LUNGYEN MINING ADMINISTRATION
RAW MATERIALS
DISTRIBUTING FACILITIES
NORTH CHINA
HANGYANG IRON WORKS
TAYEH IRON WORKS

Fig. B—Map of North China, showing the site chosen by the Lungyen Mining Administration for the blast furnace. It is quite favorable for receiving raw materials and for disposal of the product.

Limstone will be secured from deposits located about eight miles from the plant on the Peking-Mentoukou railroad.

The company has coal concessions in the Tatung coal fields, about 140 miles northwest of the plant. The coking qualities of this coal have, however, not yet been fully determined, so that for the present coal and coke will be secured from the Lou Ho Kou mines, which are about 300 miles south of the plant, on the Peking-Hankow railroad. This coal has quite a high ash content, as high as 25 per cent occasionally. At the mines the coal is washed, improving this condition somewhat, but as the process is entirely by hand, results are not as good as will be secured when the plans of the administration for an up-to-date coal washery mature. The coal is also coked near the mines, but not in the modern by-product coke ovens we are familiar with; not even in the beehive oven so common in this country. A truly native process of coking is employed. There is a pit, about 15 feet in diameter, and several feet deep. The coal is merely placed in this pit, the top covered over with coal dust or clay, and lighted from below. In about one week the coking is completed, and a coke of surprisingly good quality is secured, considering the methods used. Of course, no by-products are recovered. The coke as received at the blast furnace will be considerably higher in ash content than that which our furnace operators are accustomed to handling. However, this has been taken into consideration in the design of the furnace, and as future plans mature, this condition will be improved. The Lungyen Mining Administration plans to erect as a part of the blast furnace plant modern by-product coke ovens.

Description of Plant.

The present plant includes one 250-ton per day blast furnace, capable of being enlarged to 300 tons by relining, with raw material handling equipment and storage, boiler plant, power house and water supply development. The arrangement provides for future installation of additional blast furnaces, by-product coke oven plant, steel plant and rolling mills for producing a well diversified line of products. The present plant is thoroughly modern in all respects and is designed in accordance with best American practice.

In order that a clear idea may be secured of the location of the Lungyen plant, a small map, Fig. 1, is included. This shows principal cities, railroad lines and ports of North China as well as the location of the plants in South China. A typical section through the plant is shown in Fig. C. Photographs, Figs. 1 to 8, inclusive, show various interesting features of the plant as it appeared in August, 1922. Construction is not quite completed at the present writing, but practically nothing remains except to add the usual finishing touches.

The plant is laid out at right angles to the Peking-Mentoukou railroad, over which the ore and limestone will be received. Yard level is about 10 feet below the railroad grade at this point. Conditions allowed, however, for the provision of a small yard for the plant at the railroad grade. From this yard a high line leads to the furnace raw material handling and storage system, while other lines with a very slight grade reach the general plant level.

Coal and coke will be received over a new branch line from the southeast, connecting with the Peking-Hankow line near Peking. As product will be shipped this way, a 100-ton track scale has been installed at the entrance of the branch to the plant.

Stock House.

The furnace stock system is of the tunnel type found so satisfactory in moderate climates, and comprises a two-track concrete trestle and a tunnel running the length of this trestle. The trestle consists of concrete bents spaced 15-ft. centers, with steel track stringers carrying 80-lb. rails. Base of rails on the trestle is 20 ft. above yard level. There is a walkway on each side of the trestle throughout its total length of 660 ft. Storage capacity is provided for one and one-half months' supply of ore and one week's supply of limestone. A steel coke bin is provided located on the center line of the

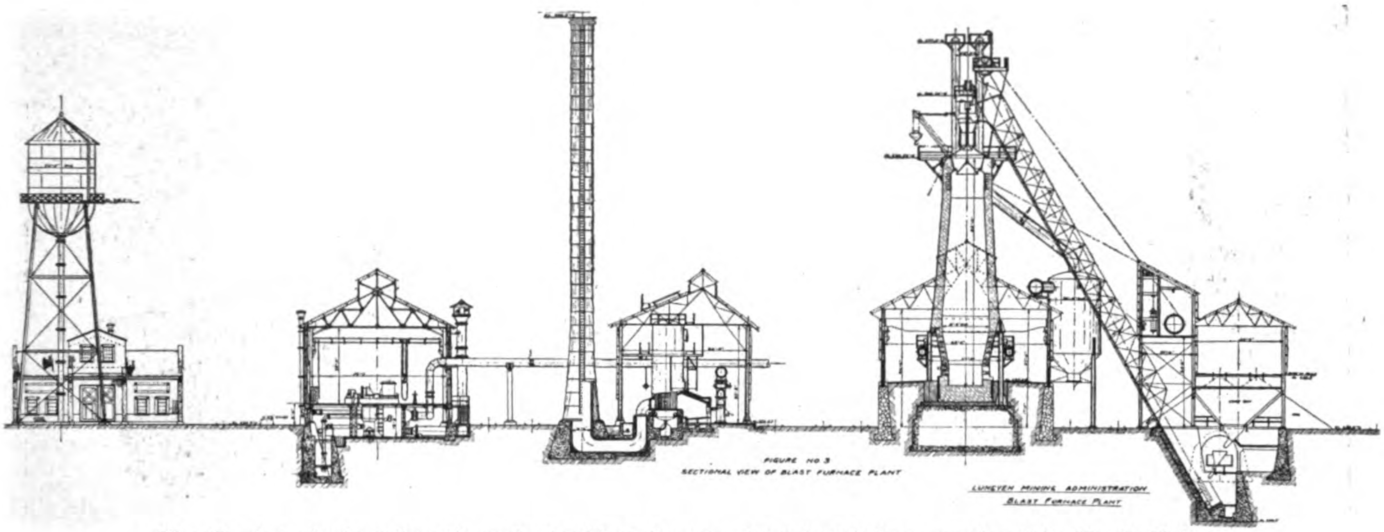
FIGURE NO 3
SECTIONAL VIEW OF BLAST FURNACE PLANT
LUNGYEN MINING ADMINISTRATION
BLAST FURNACE PLANT

Fig. C—A typical section through the blast furnace plant just being completed in North China.

furnace, ore and limestone being stored on either side. The bin is 70 feet long, with capacity for one day's operation. The coke bine is covered, ore and stone storage being in the open. Additional coke, ore and limestone will be stored in the yard, using a locomotive crane for recovery. The plant will be well taken care of for its raw materials because of, (1) short railroad hauls; (2) no closed season for mining operations; (3) ample storage capacity at the plant. The concrete tunnel is 14 ft. high, the roof of which is provided with a series of bin bottoms, each with a segmental type of gate, operated from the scale car platforms. The discharge chutes of the coke bin are provided with screens for the removal of the braize. Two scale cars were furnished by the Atlas Car & Mfg. Company and are the side dump type of 120 cu. ft. capacity each. The excavation for the tunnel has been extended at the south end and a small building erected which will serve to house the spare scale car and provide a shop for repairs.

Skip-Hoist.

The skip incline is double tracked for two 110 cu. ft. skip cars of the bucket type also provided by the Atlas Company. It is placed at an angle of 60 deg. to the horizontal. The skips are operated by an Otis Elevator Company double drum steam engine driven hoist. The drums are 72 in. in diameter, grooved for 1⅛-in. diameter hoist ropes. The hoist has a rope speed of 375 fpm. and is designed for an unbalanced load of 10,000 lbs. An automatic steam brake is provided. The hoist is located in a steel frame, corrugated steel covered building, utilizing in part the extended coke bin columns. The skip bridge passes under it. Its floor is 3 ft. 6 in above yard level. Here are also housed the steam operated bell cylinders, and the indicators for the furnace stock testers. A 5-ton trolley hoist provides for repairs or for lifting from the ground. The operator from his position can see both the furnace top and the skip pit. Stairways lead from the hoist house along the skip bridge to the furnace top, or down to the trestle level, and thence to the ground.

The Furnace Top.

The furnace top is of the standard double bell design. The gas is taken off the furnace by four uptakes, leading to four bleeders, surmounted with explosion valves. There is a cross connection for each pair of bleeders about 15 ft. above the furnace top platform. From each cross connection a downcomer leads off. The four uptakes are spaced to equalize the flow of gas over the entire top area and reduce the gas velocity, with a resultant decrease in the dust carried off by the gas. In addition, the height of the cross-pipe connection retards the dust from getting into the downcomer, so that with this type of top a decreased amount of dust is made compared to the design of top where the downcomers are taken off practically at the top platform level. These bleeders also serve to carry the bell beam platform, eliminating the separate structure required for this on some tops. The top platform is made quite large, allowing ample working space for making repairs. Platforms are provided at all essential points with guard rails of substantial construction. A 5-ton jib crane provides for raising material from the ground to the top platform or vice versa. Access is had to the top platform by interrupted flight stairs on the skip bridge or by stairs leading from the ground to the stove top platforms and thence to the furnace.

The Furnace.

The furnace is 85 ft. high, its bosh diameter is 18 ft., and the capacity is 14,000 cu. ft. It is set on a subbase of rock, much of which had to be excavated, as it extended above the required level. This excavated rock was later used in part for the walls of the cast house. There are eight structural columns and eight tuyeres. The columns are placed on a 27 ft. diameter circle, allowing for enlarging of the hearth and bosh in the future. Brackets on the columns support the bustle pipe, circle pipe and waste water trough. The bustle pipe is 42 in. diameter of ⅜-in. plate, with 9-in. brick lining and is carried on cast iron saddles which are free to move on the column brackets, thus providing for expansion. An ample number of manholes is provided to facilitate the work of relining. A bustle-pipe walkway is provided, this walkway continuing on the hot blast main to the end of the cast house, where a ladder leads to the floor level. The hearth jacket is 1¼-in. steel plate, with 3-in. thick cast iron water cooled circular plates between it and the furnace brickwork. The tuyere breast is of 1-in. steel plate, with openings for the eight tuyeres and two rows of bronze cooling plates. The bosh jacket is of the solid plate type, ⅞-in. plate being used here. There are six rows of bronze cooling plates in the bosh. The mantle is built up of 1-in. plate, and heavy angles, and is provided with a trough for collecting shell spray water. The bottom and top rings of the furnace shell are of butt strap construction, and the intermediate rings have

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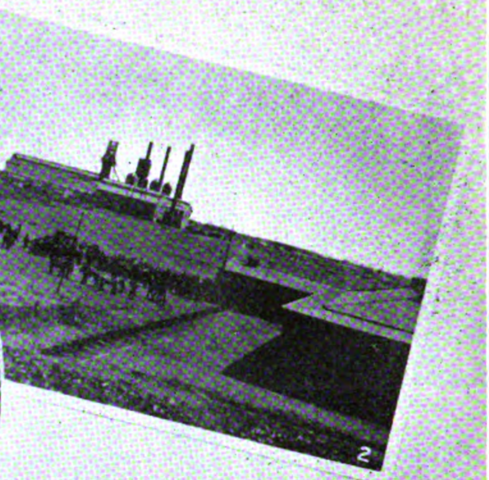
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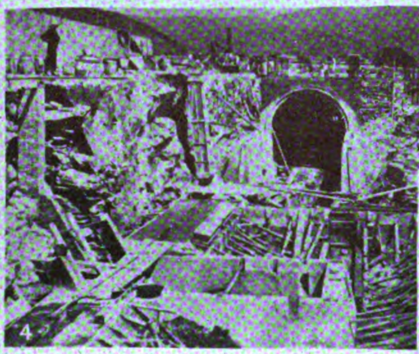
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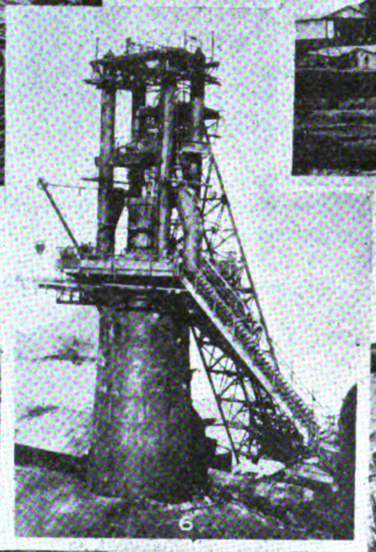
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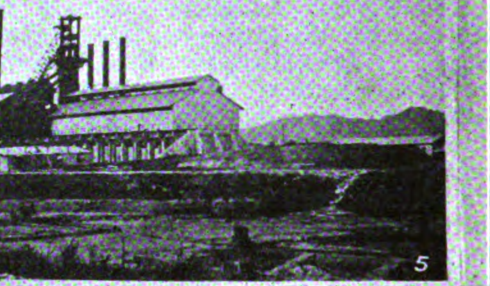
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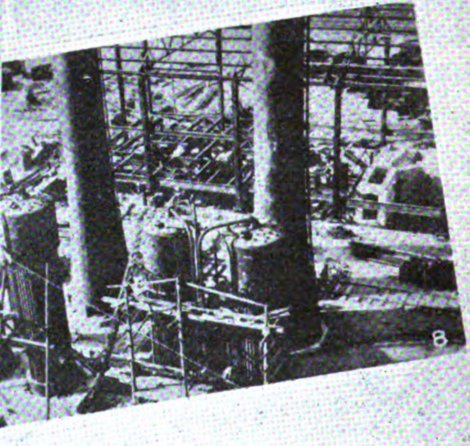
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Fig. 1—At work on the retaining walls of the 60,000,000-gallon reservoir. This picture gives a good idea of the relation of the reservoir to the plant.

Fig. 2—As mentioned in the text, various military activities have taken place near the plant, but without any consequences to it. This photograph was taken when a portion of Chang Tso Lin's cavalry was in the plant on May 1, 1922. Chang Tso Lin's forces, as most are aware, were later defeated by the forces of Wu Pei Fu.

Fig. 3—A 54-inch high urn, unearthed while excavations were being made. While this particular urn was empty when found, local histories state that it was the custom some 400 years ago to use them as coffins for the monks. The location of an ancient temple on an adjacent hill may account for its presence here.

Fig. 4—Foundations for coke bin, skip pit and tunnel. Shows clearly the splendid concrete work done. The double track trestle is carried on bents directly over the tunnel. At the top, the distant hills give a good idea of the rugged character of the surrounding country.

Fig. 5—General view of the blast furnace and accessory units.

Fig. 6—Close-up view of the furnace top. Shows clearly the arrangement of downcomers, bleeders, etc. Note the large top platform, also the well protected platforms at essential points. Stairs at the right lead to the stove top platforms.

Fig. 7—Excavation for boiler chimneys. Much of the excavating was out of the solid rock. The rock was later used in many places, displacing concrete. Note the coolies in the foreground with their small baskets, and the pack pads to ease the load.

Fig. 8—View from the furnace top, looking towards boiler and power houses in the early stages. In the foreground four of the Wickes vertical boiler units, and in back, the power house steel going into place.

triple lay riveted vertical and double lap riveted horizontal seams. Brackets on the shell bottom ring at each column, inside and outside, help distribute the shell load properly and to reinforce this ring. There is one row of cast iron cooling plates above the mantle. The shell top ring has outside structural brackets carrying the top platform and inside cast steel brackets supporting the large bell hopper. Four steel plate gas uptakes also lead from the top ring.

The furnace brick lining is of the Harbison-Walker "Woodland" brand. The present lines are designed for a production of 250 tons per day, but 300 tons may be secured without any further changes than relining. Stock line protection consists of small unit cast steel wearing plates, laid integral with the lining.

In addition to the regular iron notch, an auxiliary notch, 22½ in. higher, is provided. The working cinder notch is 90 deg. from the iron notch. There is also an auxiliary cinder notch. The product of the furnace will be foundry iron, and for this purpose is required sand cast. The Chinese foundryman has the same prejudice against machine cast pig iron as was formerly held by our foundrymen. The cast house labor required for producing and handling such a large tonnage of sand cast iron has been greatly reduced by the installation of a Shutts-Goodwin pig bed molding machine. This machine is cylindrical in shape, with four offsets on which the patterns are placed. It is mounted on a shaft with a bail attached, by which it is drawn over the sand, the cast house crane being utilized for pulling it. Beds are made up this way in about 15 minutes in comparison to two or three hours required for hand molding. Cinder will be run into Pennsylvania Engineering Works 300 cu. ft. capacity, air operated, side dump cinder ladles, and will for the present be used for filling purposes around the plant. The cast house walls are of rubble masonry, the stone having been secured mainly from the various excavations, with a large saving in concrete. The building is 63 ft. span, 218 ft. long from the center of the furnace, has corrugated steel siding, ⅛-in. plate roof, and a monitor throughout its total length. A 10-ton crane is provided for the handling of cast house materials, and for the operation of the pig bed molding machine. Water lines with hose connections extend along both sides of the building. A Berg-Brosius safety mud gun is provided.

Gas from the furnace top is led through two 4-ft. diameter downcomers, each of which enters the top of a 20-ft. diameter barrel type dust catcher. The dust catcher capacity provided is exceptionally large for a furnace of this size, and it is expected this, in conjunction with the furnace top design, will result in a gas with comparatively low dust content. Further cleaning of the gas was not desired at present, but provision is made that additional gas cleaners may be installed should they be desired later. From the dust-catchers the gas enters a common 5 ft. 9 in. diameter main leading a short distance to a large downleg, from which are taken the branches leading to the stoves and the boilers.

The Four Stoves.

The stoves are four in number, of the two-pass, side combustion type. They are 20 ft. in diameter by 85 ft. high, and have 36,200 sq. ft. of heating surface each. The brick linings for the stoves and all mains were provided in China by the Kailan Mining Administration. Fittings include 24-in. cold blast, 27-in. hot blast, 24-in gas burner, 36-in. chimney and 12-in. air relief valves and three 21-in. cleaning doors, all in the bottom ring, and three 30-in. cleaning doors in the top ring. All mains and flues are overhead. The hot blast main is 4 ft. diameter with 9-in. brick lining. The gas main is also 4 ft. in diameter, with 4½-in. lining, and 3-ft. downlegs at each stove. A 5 ft. 9 in. diameter chimney flue, with 4½-in. lining, leads to a 7 ft. inside diameter by 175 ft. high self supporting brick lined steel stack. The cold blast main is 24 in. in diameter. A 10-in. equalizer line leads from the cold blast to the hot blast main, around the stove farthest from the furnace. A counter weighted relief valve and the usual snort valve are provided. The top of the stoves is reached from the furnace top platform, or by means of stairs extending along side of the stoves and supported by them. There is a complete system of platforms around the stove tops. Hand-railings are provided along both sides of the stove operating floor, and a convenient stairs gives quick access to the cast house.

The Boiler House.

A 4-ft. diameter gas main continues to the boiler plant. The boiler house is 114 ft. long by 46 ft. wide and 35 ft. 8 in. high. It is of steel construction, with corrugated steel roof and siding. The roof is of the offset monitor type. Twenty-five hundred-hp. of Wickes vertical water tube boilers, in 500-hp. units, are installed, designed to operate at 200 lbs. pressure and 165 deg. superheat. Power Specialty Company's Foster superheaters are installed. The boilers are gas fired, with a modified Beaton type of gas burner used. Particular care has been taken in the design of the boiler house gas piping, that units may be taken off without gas leakages into the house. A bleeder is provided at the end of the gas main, removing excess gas to the outer air. Grates have been provided for coal firing. There is a 6 ft. 6 in. inside diameter by 150-ft. high brick lined self supporting steel stack for each pair of boilers. Flues are underground. The blow-off lines are led in a trench to one end of the house, where they exhaust into a blow-off tank. Other boiler house equipment includes Stets feed water regulators, Golden-Anderson triple acting non-return steam valves and Everlasting blow-off valves. This is a very complete series of platforms, suspended from the roof trusses, making all points easy of access for the operators. Trap doors in the roof over each boiler, with a walkway on the roof extending the length of the boiler house, simplify the work of removing or replacing boiler tubes. The 8-in. feed water line from pumps in the power house, and the 12-in. steam line to the power house, are in an underground trench.

Power House.

The power house is of steel construction, with brick walls and corrugated steel roof. It is 120 ft. long, 50 ft. wide and 28 ft. high from the operating floor. The operating floor is 8 ft. above yard level, so that no large amount of excavation was required for the 12 ft. 3 in. basement. For supplying the blast there are two Ingersoll-Rand turbo blowers designed to operate with steam at 175 lbs. pressure and 150 deg. superheat. Each has a capacity of 28,000 cu. ft. of air per minute at 12 lbs. pressure, or 25,000 cu. ft. at 16 lbs. When the size of the furnace is increased it is only necessary to change the steam nozzles to secure the larger amounts of blast required. There is a separate 30-in. diameter air intake provided for each blower, extending above the power house roof, and with a connection allowing the air to be drawn from inside the house, this provision being necessary on account of severe dust storms at times. The air regulating device is the single venturi type. Ingersoll-

Rand multiport check valves are installed in the discharge line from the blowers. The cold blast main leads through the boiler house directly to the stoves.

All of the electric power required at the plant is d.c. For its generation there are installed two General Electric 250-kw., 150-rpm., 250-volt, self-excited, d.c., 3-wire generators, driven by Nordberg Manufacturing Company's 20x32-in. Nordberg-Todd Unaflow engines. The engines operate non-condensing, but condensers may be added if desired. For the Ingersoll-Rand turbo-blowers there are provided two C. H. Wheeler Manufacturing Company Type "JL" low level jet condensers maintaining a 28-in. vacuum. Condensers and their auxiliaries are located in the basement. Condensing water is taken from a sump in the basement, which in turn is supplied from the plant reservoir. The discharge water returns to a hot well at the plant reservoir. Other units in the power house basement include two Worthington 20x12x15-in. horizontal duplex pot valve type boiler feed pumps, a Richardson Phoenix continuous oil filter system and a 150 cu. ft. per minute Sullivan Machine Company air compressor, with receiver. The feed water meter is of the Venturi type, installed in the discharge line from the pumps. A register indicator-recorder is placed on the operating floor. All equipment of the power house, excepting turbo-blowers and power units, is in the basement, and all steam and water lines are kept beneath the main floor, resulting in a very favorable and finished appearance. All steam and water lines enter or leave the power house by underground concrete trenches. A 10-ton capacity hand operated crane is installed to facilitate maintenance work. Particular attention was paid to the number and location of stairs leading from the operating floor to the basement. The electric distribution is underground from the power house to a steel main distributing tower. From this tower the lines are carried on a reinforced concrete pole system to the various units.

The plant lighting system is of the three-wire 115-230 volt type, with all the latest approved features. Yard lighting has been given as careful consideration as the internal lighting of various units.

Water Supply.

The water system received considerable study, as unusually severe conditions had to be dealt with. It may be divided into three subdivisions as follows: River pump house and settling basins; main, or 60,000,000-gal. reservoir; and the plant reservoir, pump house and distributing system. The amount of water available is ample, but it has the very great disadvantage that it carries a large amount of loess as suspended matter. The presence of this loess is what gives the rivers of China their characteristc yellow appearance. At certain times the loess content is as high as 50 per cent of the total, and it is impossible to use the water. Therefore a storage reservoir was required to tide the plant over such periods. The river pump house contains two 2,500-gpm. 70-ft. head Cameron pumps, driven by 75-hp. motors. The pumps are primed by means of a Wheeler Rotrex vacuum pump. The river intake had to be especially designed to provide for removal of the settled loess. The water is pumped a few hundred feet to a system of gravity settling tanks. One favorable feature in this connection is that the loess settles out very rapidly. Tests showed 98 per cent had settled out in four hours. The settling tanks are operated alternately and are of very simple construction, requiring little attendance or equipment. Water is pumped in and allowed to stand until settled, whence it goes by gravity flow through a buried concrete flume to the main reservoir. Valves are then opened and the settled loess is flushed back into the river. With the installation of the large 60,000,000-gal. reservoir, the river system may operate at the most favorable periods, but with the plant water supply assured. The main reservoir has been designed in part to work in with the plant system. It is built so that a gravity flow results to the small plant reservoir. A hill was utilized for one side, and three sides were built, with walls 20 ft. high, 10 ft. wide on top, and 90 ft. wide at the bottom. A 15-ft. depth of water is maintained in this reservoir. The warm cooling water from the blast furnace and stoves is led to a far point in this reservoir and the water from the jet condensers in the power house is sprayed here also. A 4,000-gpm. Yarnall-Waring spray system is provided. The shore operating levers of this system are a particular advantage in this case. A 20-in. cast iron pipe carries the water from the main reservoir to a 500,000-gal. capacity plant reservoir. A float operated valve in the line at this plant reservoir maintains a predetermined water level. An overflow is also provided, so that the level may be carefully maintained. The plant pump house is located at one end of the small reservoir. The general water service pump suctions are out of this reservoir. Two 2,000-gpm. 128-ft. head Cameron pumps are provided for this purpose, driven by Moore steam turbines. They pump into a 110,000-gal. water tower furnished by the Chicago Bridge & Iron Works, which supplies the general water system, but a by-pass provides for pumping direct into the system. From the water tower the main line leads to the blast furnace and stoves. This water on its return may go to the small reservoir, or to the main reservoir as before mentioned. Outlets at the furnace and stoves are sufficiently high that it returns by gravity to either place. The condenser supply water has an independent line from the plant reservoir to the sump in the power house, thus preventing any failure in supply. The discharge water from the condensers as well as turbo-blower cooling water returns to a sump in the small reservoir, from which two 4,000-gpm. 70-ft. head Cameron pumps handling water at 110 deg. F. and driven by Moore turbines, pump it to, and through, the spray system in the 60,000,000-gal. reservoir. It will be seen that with this water system practically all the water is used over and over again, with an arrangement that eliminates extra pumping and such that most efficient temperatures may be secured. The plant pump house building is of brick and concrete construction. In addition to the pumps it houses a Sorge-Cochrane hot water process water treating plant for treating boiler feed water. Exhaust steam from the power units and feed pumps in the power house, and from the pump turbines, is utilized for heating the feed water, after which it is treated, filtered and run by gravity to the feed pumps. Lines for general service water are taken off the water tower.

All pipe lines for live steam are insulated with 85 per cent magnesia, hot water and exhaust lines with air cell sectional insulation. Traps provided for the steam lines return a large part of the condensate to the plant reservoir. Water lines have been designed particularly to avoid pockets, and may be completely drained in case of shutting down the plant.

Machine Shop and Foundry.

For plant repairs and maintenance there has been provided a very complete machine shop. While at the present time the furnace product will be disposed of as foundry pig iron, it is the intention as soon as conditions warrant, to produce commercial iron products. The designs therefore include a complete machine shop, pattern shop and foundry, with a common crane runway forming a storage yard between them. The machine and pattern shops have been installed, and the runway and foundry will follow later. The machine and pattern shops are in the same building, but separated by a fire wall. The building is of steel construction, with brick walls and corrugated steel roof. It is 48 ft. wide and 140 ft. long, with a one-story leanto, housing the office, tool room and small tools, along one side. In the machine shop proper are the large tools, including 36-in. lathe, 48-in. planer, 20-in. shaper, 5-ft. radial drill and 62-in. boring mill. A locomotive repair pit is also included. A 10-ton electric crane serves the shop and the storage yard, or may even serve the foundry. The pattern shop is of two stories, the working tools which include 24-in. planer, matcher and molder, 24-in. rip saw, two 36-in. band saws, and 16-in. wood lathe, being on the first floor. The second is reserved for pattern storage. The foundry building, of steel construction, with corrugated steel roofing and siding, is 48 ft. wide and 100 ft. long. There is a leanto in which most of the equipment is housed, the main building being reserved for the casting floor. Equipment will include a cupola, capacity 6 tons per hour, with a motor driven blower, core oven, molding machines, tumbler, etc. A standard gauge track runs through the foundry, under the crane runway, and into the machine shop. There is also a 2-ft. gauge industrial track connecting these units.

Miscellaneous buildings include plant office, an up-to-date laboratory for physical and chemical testing, double track car and locomotive shed, and storehouses. Some of the construction sheds will be retained for various purposes, having been built with this idea in mind.

The consulting engineers, Perin & Marshall, prepared all plans and specifications. The American Trading Company acted as purchasing agent for the purchases made in the United States, covering about three-fifths of the total material required. All other materials were furnished in China, and proved to be of excellent workmanship throughout. The principal contractors were John Mohr & Sons, Chicago, for the platework; Hunsicker Engineering Works, Reading, Pa., for castings, forgings, etc.; the United States Steel Products Company for building steelwork; the Pittsburgh Valve Foundry & Construction Company for all steam and exhaust piping; and the American Cast Iron Pipe Company for all cast iron pipe

Construction has been under the management of the administration, with the services of a superintendent from the United States. The work was carried on largely with Chinese construction equipment, and throughout with Chinese labor. This labor proved surprisingly capable of adapting itself to the kind of work involved and very good progress resulted. There is a resident staff of Chinese engineers, most of whom were educated and secured steel plant experience in the United States.

Unusual Incidents Do Not Delay Construction.

The construction period has had numerous interesting events apart from the actual construction work. One incident illustrates clearly how closely the old and new have been drawn together in this undertaking. During the process of excavating, a large number of copper coins were unearthed and the most recent of them represented a period of over 700 years ago. These coins were accepted as local currency! Another feature has to do with the numerous political changes and military activities much heard of in the past several years. One of these recently involved a military action between forces of the two great leaders—Chang Tso Lin and Wu Pei Fu. Although this occurred quite close to the new plant, there was no interference with it, the work proceeding as usual, and one might say it merely served to put an edge on things.

It is intended to start the operation under the administration's management, with a superintendent from the United States in direct charge of the plant. In view of the results accomplished during construction it seems assured that, for even so difficult an operation as that required in a blast furnace plant, it will not be long before an efficient and capable operating force of entirely Chinese personnel will be secured.

In conclusion, the Lungyen Mining Administration is about to see the fulfillment of the first of its plans, and it is believed that interest will be keen in watching the development of this project, and the working out of further extensions.

HANDICAPS OF GERMAN IRON TRADE

The difficulties with which the Rhenish-Westphalian iron industry has had to deal have increased enormously according to advices received by the Iron and Steel Division of the Department of Commerce. The foremost handicap to smooth operation is the continuous shortage of coal and coke. Fuel for operating the mills continues to be forthcoming but sparingly, notwithstanding the agreement accepted by Ruhr miners to work six hours overtime per week, beginning September 1. Domestic coal production has apparently not increased up to expectation, and the depreciation of the mark makes it increasingly difficult for German manufacturers to purchase imported foreign coal in sufficient quantity to cover their demands. About 30 blast furnaces have had to close down as a result of fuel shortage.

TITANIFEROUS IRON ORES

Many requests have come to the Bureau of Mines for information as to the possible commercial employment of titaniferous iron ores. Particularly has interest been excited by the possibility of magnetic concentration of the titaniferous iron ores in the Lake Superior region, and many loose estimates, up to billions of tons, have been made of the titaniferous magnetites available in Lake and Cook counties, Minn. It should be stated that in general the high-grade deposits are too small and the large deposits are too lean to work. In order to utilize the large deposits, magnetic concentration would be necessary, but the nature of the material in them is such as not to promise satisfactory results.

With reference to the direct smelting of titaniferous iro nores in the blast-furnace, it has been shown definitely that these ores can be smelted readily for the production of pig iron, and large-scale tests have been run at Port Henry, N. Y., and Onehunga and Patea, New Zealand. Moreover, at some blast-furnace stacks in Norway, Sweden, and England, titaniferous iron ores were smelted as such in recent years; and there is certainly no question but that such ores can be smelted successfully and commercially. However, blast-furnace operators are generally prejudiced against titaniferous ores, and while this prejudice is not reasonable nor based on reliable data, nevertheless it exists. Information regarding titaniferous iron ores is given in Serial 2406, "Titanium," recentl issued by the Bureau of Mines.

The Trend in Blast Furnace Gas Cleaning

Controversy Between "Wet Cold" and "Dry Hot" Still Waging. The Answer Is Determined by the Individual—Comparison Between American and Foreign Equipment and Costs.

By FRED E. KLING*

SINCE the advantages of clean gas are well known, there is no longer any doubt as to the necessity of cleaning blast furnace gas for use in hot blast stoves and under boilers. The question is, how clean the gas should be and which cleaning method, wet-cold or dry-hot, should be used.

From the standpoint of the operator of hot blast stoves and boilers an absolutely clean, hot gas would be ideal, and if gas of this kind could be obtained with a simple, cheap apparatus, having a low operating cost, a great burden would be lifted from the shoulders of the blast furnace operator. Unfortunatey, however, this ideal cleaner has not as yet been developed.

The apparatus delivering the cleanest gas, cleaner than air around blast furnaces, is very expensive in first cost and operation. In case the gas is to be used in gas engines, it is, of course, necessary to go to such expense. For use in stoves and under boilers it is not required, although very desirable and efficient from an operating standpoint, but it is not efficient financially, at least not in this country where coal is comparatively cheap. In Europe, especially Germany, absolutely clean gas is used extensively in stoves and to some extent under boilers It may and very likely does pay there to go to such expense on account of the high price of coal, which is due to the coal veins being thin and located a thousand feet or more under the surface of the earth.

Absolutely Clean Gas Very Costly.

With absolutely clean gas, stoves and boilers would never have to be cleaned, just as if natural gas were burned. However, the gas cleaning plant requires that much more attention. With wet cleaning plants there is the sludge to contend with, removal of same, large settling basins, contamination of river water, high cost of repairs, of operation and of installation, large amount of power required, loss of sensible heat, etc. With the dry cleaner for absolutely clean gas (Halberg-Beth) the apparatus and the operation of same is very complicated. The gas first has to be cooled below the dew point to precipitate the moisture and then heated to prevent the cotton filter bags becoming clogged. The temperature has to be kept below 195 deg. F. so that the bags will not be scorched. The bags, of which there are 1,200 in a cleaner of a size for a 500-ton furnace, have to be replaced every nine months. The cleaner requires expert attention to keep in operating condition and a great deal of power.

It can be seen, therefore, that when using absolutely clean gas, although stove and boiler operators are relieved of trouble, and the cost of operation of stoves and boilers is reduced to a minimum, the burden is not eliminated. It is just shifted to the cleaning apparatus and the total cost of installation is considerably more than with a simpler cleaner.

Irregular Operation a Factor.

There are very few, if any, blast furnaces which can be kept in continuous operation during the life of a lining. Most furnaces have to be banked on an average once a year on account of depression, strikes, shortage of coke or other causes. If a stove can be kept in operation for a year before it has to be cleaned, the cleaning operation, if done during the shut down period of a furnace, is no detriment. If a furnace is operating continuously for two years, in which time the stoves may have to be taken off once during operation, the loss in efficiency and the increase in operating cost of a furnace is very small, when distributed over two years' operation and certainly not nearly the difference in operating cost between a simple and a complicated gas cleaner.

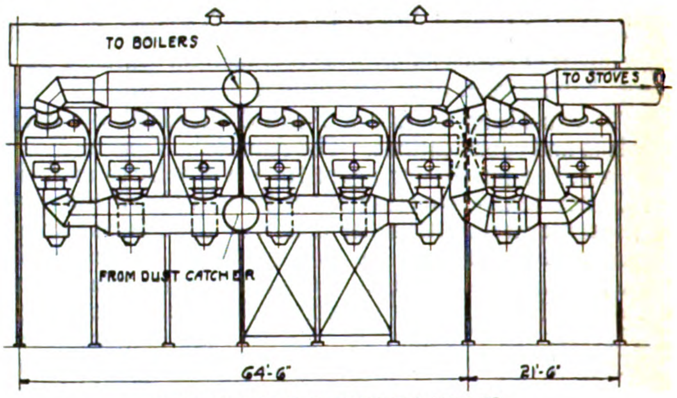
TO BOILERS
TO STOVES
FROM DUST CATCHER
64'-6"
21'-6"
KLING-WEIDLEIN 2 STAGE DRY GAS CLEANER
3,500,000 CU. FT. PER HOUR

Fig. 1—Two units are added to the six-compartment Kling-Weidlein dry gas cleaner to make it a two-stage cleaner.

In connection with boilers, coal or coke dust or both are usually burned, if not for anything else but a pilot fire, so that the boiler tubes will have to be cleaned in any event. A small amount of dust in the gas is therefore not so bad, everything considered, as is often assumed. A simple cleaning apparatus, even though not of the highest degree of efficiency, is therefore the best.

Relative to the question of applying the wet-cold or dry-hot method to the cleaning of gas; while the opinion is not unanimous for the dry-hot method, this method has so many advantages in its favor that sooner or later it will crowd the wet-cold method out of the field entirely. The reason this has not happened so far is due to the slow progress made in the development of apparatus of this character.

The Simple Method Practical.

The Kling-Weidlein dry gas cleaner, in which all of the latest developments are incorporated, will give very

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*Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.

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satisfactory results. The dust content will be about .3 grain per cu. ft. gas @ 62 deg. F., provided the dust content of the gas entering the cleaner does not exceed 3 grains and the temperature 400 deg. F. This can be obtained in cleaning the gas from a 500-ton furnace with a six-compartment cleaner having a total filter area of 768 sq. ft. and 18 in. thickness of mats. The 400 deg. F. temperature does not mean that this cleaner will not clean gas of higher temperature, temperatures up to 900 deg. F. have been recorded, but the efficiency drops off as the temperature rises. As the average temperature of gas leaving a blast furnace is 400 deg. F. the cleaner is well adapted for average conditions.

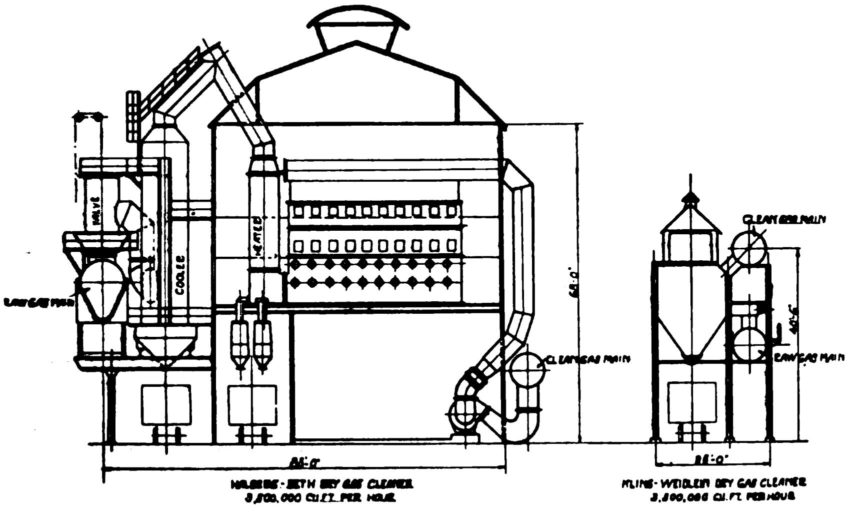
RAW GAS MAIN
VALVE
COOLER
HEATER
CLEAN GAS MAIN
86'-0"
HALBERG-BETH DRY GAS CLEANER
3,800,000 CU.FT. PER HOUR
CLEAN GAS MAIN
RAW GAS MAIN
22'-0"
KLING-WEIDLEIN DRY GAS CLEANER
3,800,000 CU.FT. PER HOUR

Fig. 2—The Halberg-Beth (left) and the Kling-Weidlein (right) dry gas cleaners of the same capacities and drawn to scale to permit comparison in size of these units.

Gas with .3 to .5 grain dust per cu. ft. is satisfactory for boiler operation; boilers have been operated with such gas four weeks before it was necessary to clean the tubes. The dust does not adhere to the tubes to such an extent and with such tenacity as the dust from wet cleaned gas. It can be blown off easily.

Small Checkers Advantageous.

In stoves with checkers 4¾ in. square (using 12x6x2½-in. tile) or larger, dry cleaned gas with .3 grain dust per cu. ft. is satisfactory. With smaller checkers the gas should be cleaned a second time, which can be done readily by adding two units to a cleaner as shown in Fig. 1, thus having a two-stage cleaner. The gas for the stoves would pass through these two compartments for a final cleaning, which would reduce the dust content to about .1 of a grain or less per cu. ft. @ 62 deg. F. With this gas, checkers could be made as small as 3¼ in. (using 9x4½x2½-in. brick).

A checker work smaller than 3¼ in. is not practical, as it requires great care in laying and if it should shift during operation, the flues will be clogged easily. Small checker openings have the advantage of intimate contact of brick with the gas and of large heating area in a stove, resulting in high efficiency. The second cleaning of the gas would therefore be of advantage in modern plants. On the other hand, for isolated furnaces, which are operated only during the peaks of prosperity, even the cheapest kind of gas cleaning apparatus, outside of a dust catcher may not pay much, if any, interest on the money invested.

With small checkers it is possible to have 90,000 to 100,000 sq. ft. heating surface in a stove of the ordinary size. Three of such stoves are sufficient for a 500-ton furnace. The savings effected by eliminating the usual fourth stove will almost pay for the installation of a dry gas cleaner. The total cost of a new blast furnace with three stoves and a dry gas cleaner is therefore not any higher, but probably lower than the cost of a furnace with four stoves and a makeshift gas washer.

For the sake of comparison, Fig. 2 shows the difference in size between the Halberg-Beth and Kling-Weidlein dry gas cleaners having the same capacity (for a 500-ton furnace), the length of the two cleaners being the same. This picture impresses upon the mind the magnitude and complexity of the former as compared with the latter. Also it brings home the fact that, although it would not pay us to invest as much money in gas cleaning apparatus as the Europeans do, we are not spending enough for this purpose if we do not install some kind of an improved cleaner in a modern plant.

The following table shows some interesting data in regard to Halberg-Beth and Kling-Weidlein cleaners:

The Cottrell electric precipitator belongs in the class of dry-hot gas cleaners and while it has been successfully applied in the metallurgical field and cement industry, it is in its infancy as far as the iron and steel industry is concerned.

The advantages of dry-hot cleaning over wet-cold cleaning are:

Sensible heat of the gas is retained.

When burned under boilers, the gas generates more steam.

When burned in hot blast stoves, produces higher blast temperatures.

No water is required for cleaning the gas.

No settling basins are required.

Less ground space required, due to absence of settling basins.

No pollution of streams.

Less labor cost in handling the dust.

One-fiftieth the power required.

Less back pressure on the furnace.

No sludge dripping from gas mains and burners.

No removal of sludge from gas main and burners necessary.

Dust can be sintered or briquetted immediately, while sludge has to be dried first.

The question of whether the moisture in the hot gas does more harm to combustion than the loss of sensible heat of cold, wet cleaned gas, has been discussed and figured out an innumerable number of times in engineering papers with probably as many advocates for the one as for the other. The fact remains, however, that according to experience, hot gas burns better than cold gas and with a higher temperature. Since the heat required to raise the 35 grains of moisture in a cu. ft. of dry cleaned gas from 400 deg. F. gas temperature to 600 deg. F. stack temperature amounts to less than 1/15 of that required to raise a cu. ft. of wet washed gas (containing only 6.3 grains of moisture) to 400 deg. F., the negligible influence of moisture in dry cleaned gas at gas and stack temperatures encountered in ordinary practice is readily seen. Another line of reasoning is that if the temperature of the waste gas from stoves and boilers is the same as the temperature of the blast furnace gas entering same, the moisture will also pass off at the same temperature as it entered and therefore not entail any loss of heat.

Such conditions are not impossible in modern boilers with economizers or air heaters, and with stoves of large heating surface. However, even ordinary equipment will benefit by the use of dry cleaned gas.

The question of whether gas should be used in gas engines for generating electric current or burned under boilers to generate steam for large turbo-generators has to be decided in each case individually, as it depends on local conditions. In a general way it can be said that where the price of coal is not extremely high, where a large arount of power is required, 10,000 kw. or more, the cost of electric current generated by a steam turbine is only about 70 per cent of that generated by gas engines, for the reason that the cost of operation, repairs and fixed charges are lower, which make up more than the saving in gas obtained with the gas engine. With turbogenerators of 20,000 kw. or larger, high steam pessure and superheat, use of economizers or air heaters, the themal efficiency of the steam station is very close to that of the gas engine station.

The cost of a turbine power station including gas cleaner is only about 60 per cent of the cost of a gas engine station plus gas cleaning plant, which not only is important during normal times, but especially during times of depression. There are other advantages of the turbine station, as for instance, the ability of taking peak loads readily, simplicity in operation, only one kind of gas cleaner, etc.

COMPARISON OF CLEANERS OF 3,500,000 CU. FT. CAPACITY PER HOUR

	HALBERG-BETH	KLING-WEIDLEIN *Single Stage* 6 *Compartment*	 *Two Stage* 8 *Compartment*
Cost of cleaner without foundation	$300,000	$90,000	$120,000
Ground space required, sq. ft.	6,500	1,800	2,900
Power required, kw	90	1.5	1.8
Resistance through cleaner, inches of water	6 in.	1 in.	1 in. for boiler gas 2 in. for stove gas
Temperature of gas leaving cleaner	175 deg. F. average, having been heated from 120 deg. F.	350 deg. average	350 deg. average
Dust in cleaned gas, grains per cu. ft	.004	.3	.1
Life of filter medium	9 months	Probably 5 years or longer, filtering medium which has been in use 3 years is still in good condition.	
No. men required for operation	Several	None, except for inspection once a day and dumping ot dust every other day.	
Cost of cleaning 100,000 cu. ft. gas, including repairs and fixed charges	$0.14	$0.025	$0.034

TITANIUM AS A STEEL ALLOY

The use of titanium as an alloying element for steel is much shrouded in secrecy. According to information supplied to the Bureau of Mines, carbon-free ferrotitanium has been employed in Europe for making an electric steel containing 5 to 7 per cent titanium. Titanium increases the hardness of steel, and experiments on titanium steels have been made by Guillet, Braun, and Lamort. It has been shown recently by Gillet and Mack in Bulletin 199 of the Bureau of Mines that fair recoveries may be expected with carbon-free ferrotitanium, provided the alloy is added at the end of the heat and the steel is very hot. Complex iron-chromiumtitanium alloys have been patented for use in making chromium steels—for example, 55 to 75 per cent chromium, 5 per cent titanium, 5 to 10 per cent carbon ,and 3 4to 1 0per cent iron.

BETHLEHEM STEEL ACQUIRES MIDVALE

E. G. Grace, president of the Bethlehem Steel Corporation, recently announced that at a special meeting of the Board, contracts for the purchase of the plants and other assets of the Midvale Steel and Ordnance Company, and of Cambria Steel Company, have been authorized, excepting the ordnance plant and other business located at Nicetown, Pa.

The Bethlehem Steel Corporation besides providing for assumption of bonds and other indebtedness of the two companies, will issue about $97,650,000 of common stock of which $95,000,000 will go to Midvale Company for distribution on dissolution to its stockholders, and balance to holders of Cambria stock now owned by Midvale. As a result, stockholders will receive for each two shares of $50 par value of Midvale stock, $95 par value of Bethlehem common stock, together with a pro-rata share of stock of new corporation to which the Nicetown plant and its assets are to be transferred.

Mr. Grace stated that the directors of the Bethlehem Company authorized these acquisitions in pursuance of its policy of building up a complete line of steel products. Through the acquisition of the two companies, Bethlehem will acquire plants at Coatesville and Johnstown, Pa., and Wilmington, Del., and important developed iron ore properties in Michigan and Minnesota, as well as developed coal properties in Pennsylvania. The acquisition of the two companies will give Bethlehem important lines of steel products which it does not now manufacture, such as wire rods, and wire products, steel freight and mine cars, steel wheels, boiler tubes, agricultural implements and parts, etc.

Bethlehem's annual ingot capacity will be increased from 4,890,000 tons to 7,600,000 tons by purchase.

The capitalization of Bethlehem after the deal has been completed will amount to $213,500,000 funded debt; $62,000,000 7 per cent preferred stock and about $180,250,000 common stock. The combined investment in property and plant less depreciation and depletion will be about $465,500,000 and aggregate net quick assets about $133,700,,000.

Stockholders' meetings and other proceedings will require 60 to 90 days before transaction can be concluded.

Developments in the Open Hearth

Gas Producer Development and the Possibilities of Coke Oven Gas—Furnace Valves, Door Frames and Ports—Suggesting the Evolution of an Open Hearth Similar to Modern Blast Furnace.

By HERBERT F. MILLER, JR.*

IN judging the work of open hearth furnaces it is often well to consider the effect of various fundamental conditions on the capacity of furnaces for production and on the quality of steel produced before drawing conclusions in regard to the superiority of one design of furnace over another. Some thought should be given to the effect of the amount and quality of the molten pig iron used in the furnace charge. For instance, a pig iron running:

1.00 per cent Silicon
1.50 per cent Manganese
0.15 per cent Phosphorous
0.04 per cent Sulphur

would enable the furnace operator to produce 30 per cent more tonnage with about 15 per cent less real cost than could be produced with the same furnaces if his pig iron fluctuated over a range as follows:

.60 to 2.50 per cent Silicon
.50 to 1.30 per cent Manganese
.30 to .50 per cent Phosphorous
.04 to .18 per cent Sulphur

With pig iron of fluctuating analysis such as that just given the limestone charge would need to be increased over 50 per cent above the amount required when a good quality of pig iron is used.

Record tonnages of open hearth furnaces have generally been made when 55 to 65 per cent of the metallic charge has been A1 basic hot metal.

Another effect to consider is that of the physical condition of the coal upon the production and quality of producer gas. The tonnage of an open hearth furnace using producer gas made from coal slack may be increased 25 to 50 per cent by using clean lump coal instead of coal slack. At the same time the coal consumption per ton of ingots will decrease between 15 to 30 per cent. The screening necessary to get clean lump coal produces a large amount of coal slack. The full disposal of this coal slack is a problem in a large steel works. Coal slack is not a desirable ingredient to use in large percentage to produce blast furnace coke because it lowers the quality of the coke chemically and physically.

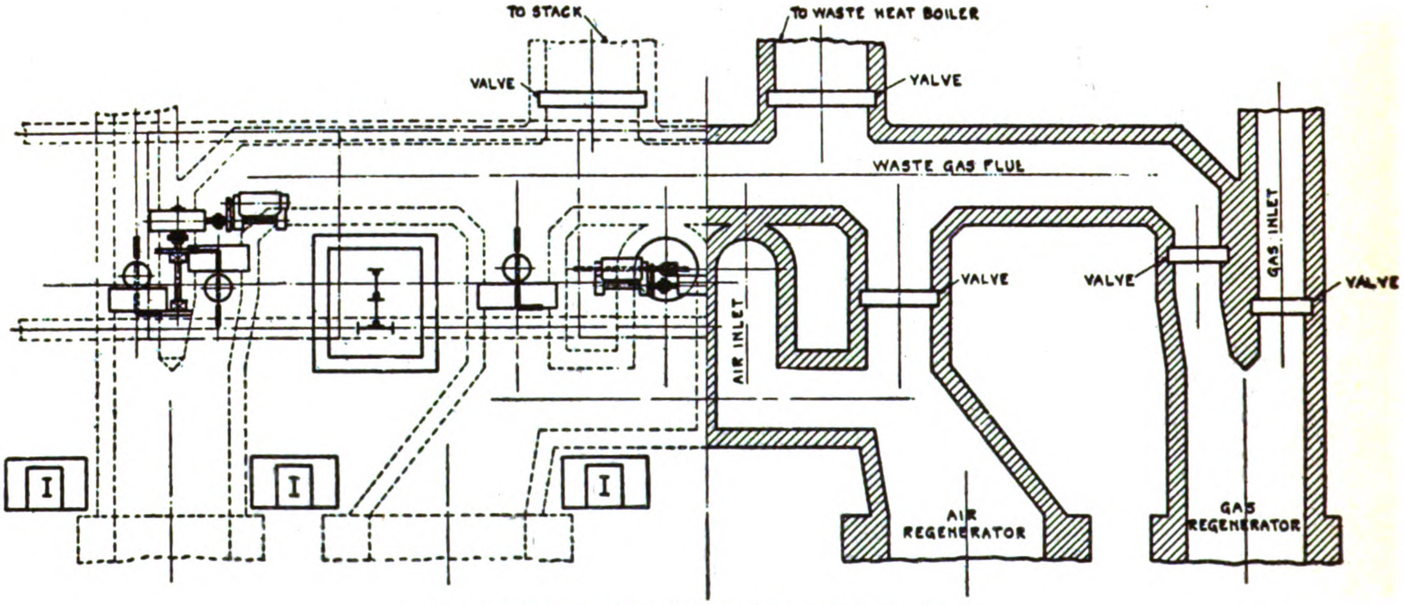

Fig. 1—Arrangement of flues for reversing valves.

German Gas Producer Developments.

The above, together with the fact that the operation of gas producers using bituminous coal for fuel is attended by an irregular supply and quality of gas due to the necessity of cleaning the producers of clinkers and ashes as well as cleaning the gas sewers of soot, causes us to study a phase of gas producer practice as developed in Germany during the war. There the bituminous coal was coked to recover the valuable by-products. Then this coke, the physical and chemical composition of which may have been unsuitable for blast furnace use, in the same way that coke made from coal slack would be unsuitable, was charged into a producer built like a miniature blast furnace. Air under pressure was blown in through a number of water cooled tuyeres. The ash of

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*Superintendent Steel Division Bethlehem Steel Company, Lackawanna Plant.

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the coke melted and was flushed off through a cinder notch. Thus were eliminated clinkering, holes in fires, and like evils. A small amount of open hearth slag was added to each charge of coke to flux the ash. By charging open hearth slag a free running slag was obtained and the iron content of the open hearth slag was recovered as a by-product.

The introduction of air under pressure gives a producer of this type a capacity about five times greater than that of a gas producer of equal dimensions using coal for fuel, and steam induced air supply. Melting and flushing off the ashes insured a constant flow of rich gas low in CO_2, and this gas is clean and free of soot. There is no unconsumed fuel from producers of this type.

The analysis of such a gas approximates:

Under 1.00 per cent	CO_2
1.40 per cent	CH_4
.20 per cent	H
33.00 per cent	CO
Balance	N
Btu. about	120 per cu. ft.

The great gas producing ability of these producers indicates that a large central gas station with gas lines to all parts of the plant would be possible and practical. The objection raised to this fuel is the same as that raised against debenzolized coke oven gas: the flame cannot be seen in an open hearth furnace and therefore is hard to regulate, causing excessive melting of the furnace brickwork. The solution of this difficulty seems to lie in the use of known volumes of gas and air, and the aid of optical pyrometers in operation.

The possibilities should carefully be studied of extending to every steel works the practice of coking all of the soft coal used, recovering the by-products, and then producing gas from the coke for general use around the plant, including the heating of the coke ovens.

Furnace Equipment.

Valves—An excellent type of open hearth valve which has been developed this year is a six-way reversing. Only one valve is needed for a furnace and but one gas connection to the valve. They claim that it is easily operated, mechanically or by hand; and that water cooling is reduced to a minimum, the gas seal is perfect, and the flow of gases is not impeded.

Another type of reversing valve produced by another company is designed to give increased effective draft at the regenerators due to the elimination of the friction loss, caused by the usual four right angle turns and restricted passages of valves that are situated above the flues, which friction loss may amount to 50 per cent of the total stack draft. Since they present no exposed water, and since the dampers are raised out of the flues during passage of the gases, the heat loss through the valves is inappreciable. This is particularly important in furnaces having waste heat boilers where all of heat of the waste gases is wanted to produce steam.

Door Frames—The same company has also produced a door frame designed to do away with brick door arches and give increased door openings in open hearth and heating furnaces. The increase of size of door openings is intended to afford opportunity to charge larger sized scrap and to make easier the charging of large amounts of light scrap. In the case of the heating furnace, the elimination of the door arch enables the furnace to have a lower roof and thus to speed up the heating of the steel.

Furnace Ports—A type of furnace is being experimented with by several steel plants, in which the vital principle is the ready variability of port areas. The incoming port areas are restricted, the air is furnished under pressure, and the increased velocities result in rapid and intimate mixtures of fuel and air. The outgoing port areas are enlarged to permit the exit of the increased volume of burned gases at a reduced speed, thus completing combustion over the furnace hearth instead of in the outgoing ports and checkers. A late application in a western steel works includes a double water-cooled gas port with a water-cooled damper between the ports.

The double port design has been found advisable in order to break up the gas stream and at the same time direct the flame so that it will not impinge directly on the piled stock during the melting down period, but will be deflected toward the roof and side walls. Two port furnaces of this type have proven in practice to give decidedly longer front and backwall life than the single port furnace. The use of one single damper at each end of the furnace, same being situated on the center line of the furnace, reduces the number of moving water cooled parts by one-half and at the same time, since the major portion of the waste gases are drawn down the center line of the furnace, the gases are better held away from the front and backwalls.

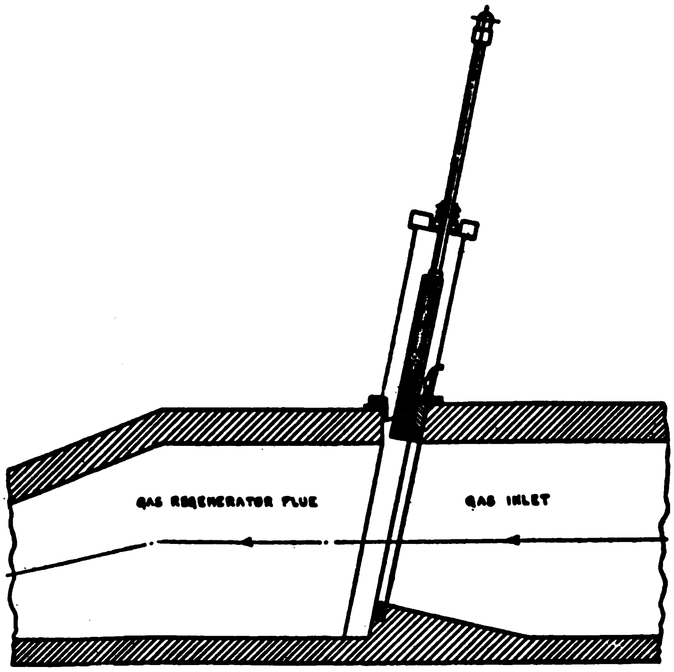

Fig. 2—Section through patented valve unit.

Furnaces of this type are reported to have given increased tonnage with lower fuel and operating costs. The Combustion System used on this furnace is applicable to all types of fuel; but it is claimed that this is the one furnace design which permits of economically and satisfactorily using straight debenzolized coke oven gas.

Evolution of the Future Open Hearth.

Side by side with the foregoing record of developments in open hearth construction and operation is a trend of speculative thought on future open hearth evolution. Referring to the writer's article, "Methods of Using Fuel in Open Hearth Furnaces," given to the meeting of the A. I. & S. I. in May, 1922:

"A means of using compressed air with open hearth fuel is now being developed. From the outset these systems have each given excellent results in increasing tonnage and reducing fuel costs. Some operators, however, doubt whether the use of compressed air with fuel will not tend toward excessive rebuilding costs, unless more refractory furnace linings able to resist the high temperature and intense flame can be developed. Here is a condition which would seem to limit the development of the open hearth furnace, but is not this seeming limitation a hand pointing the way to a further necessary evolution of open hearth furnace design? One cannot help but think that the construction of open hearth furnaces will progress along the lines of the modern high power blast furnace. By this is meant that the hearth and end walls, including the roof, will probably have to approach in similarity the construction of the bosh of a blast furnace, having roof and wall coolers alternating with the brickwork.

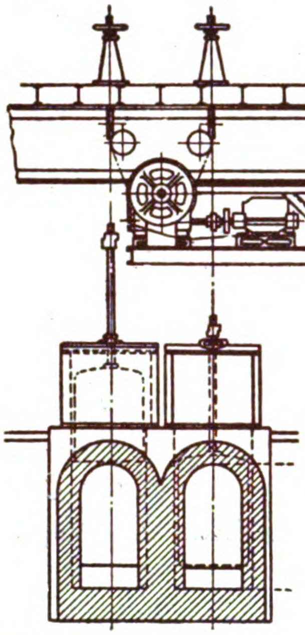

Fig. 3—Typical valve operating mechanism.

"The present air and gas pressures are much too low and I see no reason why these should not run up into the pounds instead of ounces per square inch. We have but to observe the acetylene burner, the pressures used and the rapidity of work done under these pressures, to sense the potentialities in an open hearth furnace with high pressure air and gas.

Open Hearth Construction May Progress Along the Lines of the Blast Furnace.

"Furthermore the blast furnace may also teach us that with proper sealing of the doors, and sheathing the walls in steel plates, air and gas may be introduced into the furnace under pressure through small orifices and exhausted continuously without the necessity for intermediate dampers.

"I have no doubt that heats charged with scrap and cold pig iron can be tapped in three to four hours after starting to charge when conditions governing the use of high pressure air and gas are further developed. If the foregoing methods become actual realities, we could not under present methods of charging furnaces reap the full value of the development. For now with the ordinary furnace the delays in getting furnaces charged are large when the usual run of purchased scrap in large proportions is used. Indeed, even under favorable conditions with quickly poured hot metal forming as high as 65 per cent of the charge, the delays mount up in a shop in full operation.

"The present methods of charging furnaces having about reached their limit in speed, any further improvement will have to be by entirely changing the method of getting the stock to and into the furnace. There is at present too much handling of the stock, which is taken from the incoming cars, divided into minute parts with much labor, and charged into the furnaces, under the same handicap. This with light scrap consumes hours. The errors in weighing small quantities of scrap at a time to make large totals, must be large.

"To overcome these difficulties a few suggestions are outlined. For the purposes of fast charging and for a high pressure open hearth furnace, the present design of a blast furnace bosh seems to be most suitable, although it may be possible that the rectangular hearth has some advantages. The principle of charging and applying the fuel will be the same in either case. Such a furnace would have a water cooled top, removable by sliding, rolling, raising or other means. Situated above the furnace would be a car dumper and magnet cranes to charge the furnace by carload lots or in small lots direct from the car. In this way 30,000 lbs. of limestone and 200,000 lbs. of scrap could be charged into the furnace in less than 15 minutes.

"This method would eliminate charging buggies, and stock yard operation as we now know it; avoid necessity of cutting scrap to charging-box sizes; do away with the skull cracker to a large extent; reduce the time on invoice cars several hours; charge furnaces in minimum time; and obtain accurate weights of the charges.

"In this furnace construction, I would retain the flat bosh plate of the blast furnace, using magnesite brick between the plates. The slag line could be water cooled enough to resist the scorifying action of the slag and thus eliminate the present practice of making bottom after each heat. The drop in temperature needed to prevent chemical action on the refractories is not very great; and the cooling action on the slag line would cause a growth of slag covering that would automatically regulate itself in thickness. The fuel and air, both preheated, would pass into the hearth through circular water cooled tuyeres arranged similarly to the tuyeres, blast pipes, and bustle pipe of the usual blast furnace practice. From the side and below the top of the furnace should come one or more downtakes after the present blast furnace design. These should lead to the regenerators. Valves similar in design to the present blast furnace equipment would be necessary to cut the furnace off from either regenerator or to bring them into communication as furnace conditions require. In like manner the regenerators should communicate with the tuyeres.

"The regenerators being necessarily large and the temperature of the waste gases high, it would be advisable to have the gases pass horizontally through the checker work, thereby eliminating the danger of crushing the checker brick by a heavy load while under high temperature which would occur if blast furnace design of vertical stove were used.

"With water cooled walls and roof, any kind of gas or fuel could be used, as we would be dealing with known volumes and known pressures on both air and gas. Liquid fuel would be most easily adapted to this type of construction. Danger to the furnace walls in charging, etc., would be easily overcome by properly designed chutes above the furnace and by making the

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distance between the furnace walls or diameter of hearth great enough to prevent much contact from falling stock."

The above paragraphs may start other trains of thought on this subject which will help develop the art of steel making so as to utilize a larger proportion of the heat energy in fuel than at present and to reduce the great expenditure of human energy in the whole organization of an open hearth steel works. This would result in cheaper steel of more uniform composition than is now possible.

Control of Sulphur in the Basic Open Hearth Process

Excessively High Temperatures Necessary to Remove All Sulphur in the Open Hearth—Reduction at Blast Furnace Advantageous—Selection of Low Sulphur Fuels Should Be Carefully Watched.

By SYLVESTER V. WILLIAMS*

SULPHUR can be eliminated in the basic open hearth process by the influence of lime to the extent of 57.4 per cent of sulphur present; by desulphurization during melting and oring, 12 per cent; by addition of .60 to .75 per cent of manganese in the form of recarburizer reducing the content about .01 per cent or eliminating from 20 to 30 per cent of sulphur present. With 50 to 70 lbs. $CaCl_2$ per ton of steel added at intervals, a reduction of sulphur present of 80 per cent can be brought about with a limey slag and high manganese content. To completely remove sulphur from iron or steel it must be converted into a form which is insoluble in the steel and soluble in the slag. Such a form is calcium sulphide. To produce calcium sulphide the slag must be completely free from metallic oxides lest FeS be formed according to:

$$FeO + CaS = FeS + CaO$$

returning the sulphur to the steel. To maintain freedom from oxides, reducing agents such as calcium carbide or ferro silicon must be used and enormously high temperatures must be employed. The open hearth furnace is not able to reach these high temperatures as yet, hence complete elimination of sulphur is not possible.

There are several channels through which sulphur enters steel in a basic open hearth process:

1. Through the pig iron.
2. Through the scrap.
3. Through the fuel.
4. Through fluxes such as ore, limestone or recharged steel slag.

It therefore behooves one to minimize or eliminate the entrance of sulphur through these channels and, if impossible to eliminate them, to control their increasing amount in the basic open hearth furnace by:

1. The use of a limey slag which runs about 50 to 60 per cent CaO and to circulate the bath so that more metal comes in contact with the slag.
2. The addition of manganese.
3. The addition of manganiferrous ores.
4. Spraying the scrap with a fire clay wash and introducing pig iron under the slag.
5. The addition of $CaCl_2$ in small lots of 50 to 70 lbs. per ton of metal.
6. By the addition of calcium carbide to the ladle or bath.

METHODS OF MINIMIZING OR ELIMINATING SULPHUR FROM ENTRANCE TO STEEL

1. SULPHUR IN PIG IRON

A. Elimination by High Manganese Pig Iron Practice.

The percentage of sulphur eliminated in the basic open hearth depends a great deal on the per cent of sulphur in the pig iron used. The cost of eliminating the sulphur is much higher in any other process than the blast furnace. Therefore we should economically control the sulphur content in the blast furnace.

From experiments carried on at the Bethlehem Steel Company, during 1920, it was concluded: First, that high manganese iron is a help rather than a hinderance in blast furnace practice; second, that high manganese iron improves the quality of basic open hearth steel without reduction of tonnage, or practice, or other injurious effect; third, that due to better surface conditions steel made from it shows increased yield with ordinary rolling practice.

If the manganese in the hot metal is kept around 2 per cent it is possible for the blast furnace to be run on high sulphur iron with leaner slag, which means increased tonnage and decreased fuel ratio.

Samples were taken of the metal as it was tapped at the furnace, and again as the metal arrived at the open hearth mixer with average time between sampling of 80 minutes.

TABLE I

Mn at Blast Furnace	S at Blast Furnace	S at Open Hearth
1.17	.068	.032
1.26	.099	.044
1.35	.0110	.030
1.41	.086	.053
1.50	.073	.023
1.62	.071	.021
1.77	.052	.035
1.80	.077	.050
1.98	.073	.034
2.04	.070	.033
2.10	.049	.040

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*Open Hearth Department, National Tube Co., Lorain, Ohio.

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The higher the content of sulphur, the higher the elimination of sulphur per given amount of manganese present. For iron with less than 1.80 per cent manganese, it is necessary to hold longer in the ladle to get maximum elimination. Silicon should be below 1 per cent as any excess forms $FeOSiO_2$ which unites with MnS:

$$MnS + FeOSiO_2 = FeS + MnOSiO_2$$

and the FeS goes to the metal. To keep SiO_2 content as low as possible dolomite can be used as a runner at the blast furnace.

B. Elimination of Sulphur in the Mixer.

The underlying principle of the elimination of sulphur in the ladle can be carried on in the mixer. If content of manganese is not high enough some can be added, in any case the SiO_2 must be kept low. The ratio of

$$\frac{SiO_2}{MnO} = .80$$

gives the greatest removal of sulphur, but some removal takes place with a ratio of 1.28. 1.09 is the ratio of manganese in $MnOSiO_2$, hence 1.09 — .80 = manganese necessary to form MnS. If the ration falls low such that there is not sufficient MnO to combine with all the silica, manganese or manganese ore such as pyrolusite can be added to increase the ratio and thus eliminate the combination of iron and silica to form $FeOSiO_2$ which has the effect of driving sulphur back into the iron.

The manganese coagulates and floats on the surface with the slag.

TABLE II

Per cent Sulphur Removed	Ratio of $\frac{SiO_2}{MnO}$
50	.80
38	1.00
37	1.08
34.5	1.09
29	1.17
21	1.19
16.3	1.25
13.6	1.79
12.9	1.94

The lining of the mixer and ladle must be of basic material to obtain good results.

C. Elimination of Sulphur by the Wash Metal Process.

It has long been known that oxides of iron, calcium oxide and fluid iron agitated in a rotating or suitable furnace will eliminate the sulphur by oxidation. This was worked up by Sir Lowthian Bell and also by Krupp, and is used in some industrial plants in this country.

TABLE III

Sulphur	
Before	After
.09	.029
.113	.024
.210	.036
.05	trace

Thus we have an expensive means of eliminating the sulphur in pig iron.

D. Elimination of Sulphur in Pig Iron by Saniter Process.

E. H. Saniter, F. C. S., experimented to ascertain the effect of prolonged contact of lime with sulphury iron at high temperatures, and found that the results were varying. Knowing that chloride of aluminum and chlorides such as calcium were readily reducible to the metallic state, he tried calcium chloride with very beneficial results, the oxychloride being a powerful desulphurizing agent.

TABLE IV

No. Exp.	Time Hrs.	Sulphur		Mixture Used
		Before	After	
4	2¼	.38	.03	lime
6	1¼	.30	.12	lime
15	½	.42	trace	lime 90%, $CaCl_2$ 10%
16	½	.42	trace	lime 90%, $CaCl_2$ 10%

From these experiments the following results can be concluded: First, that lime alone removes a considerable quantity of sulphur from iron if time be prolonged; second, that a mixture of lime and $CaCl_2$ in one-half hour or shorter space eliminates all the sulphur. Fluor spar in conjunction with lime has considerable desulphurizing properties, but it has the disadvantage of its comparative infusibility, and has high cutting action on basic materials.

From these experiments he patented a process for the removal of sulphur from pig iron. This process was used and is as follows:

TABLE V

No.	Class Fe.	Sulphur		Silicon		Mixture Used
		Before	After	Before	After	
1	No. 5 Hematite	.22	.06	1.6	1.2	$CaCl_2$ +
2	Hard Forge, 1.5 +	.30	.06	1.7	1.4	hydrate
3	Grey Iron	.07	.008	2.2	1.6	lime.
4	Basic Iron	.197	.072	not cal		"
8	Basic Iron	.102	.032	.56	.32	"
11	Basic Iron	.083	.020	.37	.09	"
14	Basic Iron	.060	.008			"

Average elimination of 73.6% S
Average elimination of 35.77 Si

A mixture of lime and calcium chloride is prepared which will melt at the temperature of the molten slag. This is placed in the ladle or receiver and kept in position. In first warming up of ladle coke gas may be used to warm up the mixture, when in continual use, the residual heat of the ladle is sufficient. The receiver is then filled with iron from the blast furnace, the heat of which melts the mixture, and the latter rising to the top through the molten metal removes the sulphur as a sulphide of calcium. No reducing condition need be set up. Silicon can be eliminated by adding hydrate or carbonate of lime. The following table gives results obtained in practice:

Composition Slag	
$CaCl_2$	39.1
Cas	5.8
CaO	38.6
SiO_2	12.9

Four-ton ladle used lined with fire clay, unattacked by slag. Conclusion: These results speak for themselves.

II. SULPHUR IN SCRAP

In basic open hearth practice there seems to be no way of reducing the content of sulphur in scrap, and as the metal of this scrap may have passed through several cycles of life, there is bound to be an increasing sulphur content with the varying uses it has been subjected to. As a possible means of eliminating it, I recommend that it be melted down in an open hearth, and as much of the sulphur as possible eliminated. Then the molten metal should be tapped and high manganese recarburizer added. Then this metal is to be placed in a mixer giving the MnS time to coagulate and float with the slag. This metal then can be used as a jigger in the ordinary process.

III. SULPHUR IN FUEL

The control of sulphur in fuel is growing more important as the grades of fuel seem to be increasing in sulphur content.

A. Elimination of Sulphur from Coal.

In the case of coal which is used in various ways, if the coal is crushed to 100 mesh and washed most of the sulphur is eliminated. All of the sulphur in the form of minerals is taken out, but that in combination with hydrocarbons is not eliminated.

B. Control of Sulphur in Oil and Tar.

In the case of oil and tar there is no method as yet of elimination of the sulphur, hence a low content must be specified.

C. Elimination of Sulphur from Producer Gas.

1. In the case of producer gas, if there is SO_2 or H_2S present, it tends to break down under the presence of CO at the temperature of the early stages in the open hearth process to CO_2 and sulphur which is in vapor form and will readily be absorbed by the scrap. It has been found advisable to spray the scrap with fire clay wash which will check the absorption of sulphur until a temperature is reached where practically no absorption takes place and the scrap then melts and the bath is covered with slag. Al_2O_3 can act either as a base or acid, hence no injurious results are encountered from the use of fire clay.

2. A method of removing the sulphur from the gas is by passing it through iron shavings which are heated so as to absorb the sulphur, the shavings being replaced from time to time. With this scheme the sensible heat of the gas is not lost while if the gas is washed with lime water or water, the sulphur is eliminated with the loss of sensible heat.

D. Sulphur in Ore and Fluxes.

The content of sulphur in ore and fluxes is very low and if necessary roasting will eliminate the sulphur very satisfactorily.

METHODS OF CONTROLLING SULPHUR IN BASIC OPEN HEARTH PROCESS

A. Use of Limey Slag.

It has long been known that the presence of an alkaline earth such as CaO which unites with any sulphur present in the form of SO_3 to give $CaSO_4$ and that no temperature is reached in the open hearth which will break it down. However iron itself will break it down accordingly:

(1) $4Fe + CaSO_4 = FeS + CaO + 3FeO$

and the FeS dissolves in the iron. But if the slag is highly oxidized the reaction is checked. Then with the FeS in the iron we have direct action with the lime:

(2) $FeS + CaO = CaS + FeO$

The CaS is insoluble in the metal hence goes with the slag. But if too much of the FeO goes in the slag we have the action reversing. Hence it is very important, since we need oxides to check the first reaction, that the oxides be other than FeO. Here is where manganese greatly assists the elimination of sulphur:

$Mn + FeS \longrightarrow MnS + Fe$

$2MnS + 3O_2$ — from oxidizing flame — $2MnO + 2SO_2$ keeps equation (1) in check; also

$MnO + FeS — MnS + FeO$

If FeO goes to slag it acts with Mn according to:

$FeO + Mn — Fe + MnO$

and carbon being burned off will tend to reduce FeO to Fe.

From this we can see that there are very complex reactions taking place and provided the equilibrium is such between the slag and metal that FeO is kept out of the slag, the effect of a limey slag with manganese is very great. Most of these reactions take place only between slag and metallic surface, therefore it is quite evident that the more circulation of the bath, the more metal will come in contact with slag and consequently the higher the elimination of sulphur.

The methods of controlling sulphur discussed are used in various plants, depending on location and economical conditions. At the Lorain Shop, ferromanganese is largely used as the constituent to be added to combat sulphur with the limey slag. Here the fuel and scrap are very low in sulphur and on special orders the company's own scrap is used and the percentage of sulphur in hot and cold metal is kept well down in the lower limits.

TABLE VI

Influence of Lime Additions Upon the Elimination of Sulphur*

% of Sulphur in bath when melted	% Sulphur in Steel	Pounds Lime added
.078	.033	294
.24	.078	410
.60	.033	160
.78	.033	164

An average elimination of 57.4%.

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*Iron Age, Vol. 57, page 811. E. F. Thompson.

B. Use of Manganese.

1. "The manganese added in the metal in passing out may carry some sulphur with it."

Note: Same action as takes place in mixer.

2. "The manganese reduced from the slag during dephosphorization effects an elimination of sulphur."

A strongly oxidizing flame with high content of manganese in slag oxidizes the MnS to $MnO + SO_2$, the SO_2 escaping. Then MnO may act as a carrier between metal and slag to carry off sulphur from the metal. Here also circulation of the bath increases the elimination.

3. "Some of the manganese added in the ferro does undoubtedly leave the bath again, carrying with it small quantity of sulphur." This reaction is similar to mixer elimination.

The above quotations are from Stead, Harlord and Hardisty.

The manganese is added directly to the bath with the result of liquidation of sulphide of manganese. The extent of this reaction varies with the numerous conditions which effect it, but the usual addition of 0.60 to 0.75 per cent of manganese in the form of a recarburizer reduces the content about .01 per cent.

TABLE VII

No. Charge	Initial Metal Per Cent C	Initial Metal Per Cent S	Before Recarb. S	Steel Ingot S
204	.80	.05	.05	.03
203	.78	.06	.06	.04
202	1.25	.06	.05	.04
200	2.15	.06	.03	.02
*201	2.40	.07	.05	.06
200	2.15	.06	..	.02
204	.80	.07	..	.03

The condition favoring desulphurization in this way does not depend on slag* but high content of sulphur may give resulphurization.

C. Addition of Manganese Ore.

At low temperatures sulphides of iron break down under the higher oxides such as Fe_2O_3 or Fe_3O_4 forming SO_2 which escapes.

$$FeO_3 + Fe_2S \text{ — } FeO + Fe + SO_2$$

At the higher temperatures of the open hearth higher oxides do not exist. There may be some FeO but it needs a high oxidized slag to reduce the FeS. So, therefore, if we add Fe_3O_4 in form of high grade mill scale or ore it tends to bring about a reaction according to the above and the uniting of carbon with oxygen to form CO_2 which also escapes with the SO_2, giving the bath a very vigorous boil. It is known from analysis of the metal after one of these boils that the sulphur content is low and tends to decrease with the carbon but after a sufficient reduction in carbon takes place the sulphur content tends to increase due to absorption from slag or fuel.

Manganiferous ore may act in the same way as the manganese. The reduced manganese will tend to form MnS which will increase its eliminating of FeS over iron ores.

TABLE VIII

Desulphurization During Melting and Oring*

No. Charge	Reduction % S	Ore added with the metal %	Mn in Ore in %
1564	.18	2000	.40
1546	.15	2000	.40
1626	.09	1500	.30
1569	.09	1500	.30
1630	.11	1500	.30
1500	.11	2000	.40

D. Discussion of Fire Clay Wash, Under Method of Eliminating Sulphur in Fuel. Also the speed of melting down tends to eliminate sulphur absorption.

TABLE IX

Unprotected Scrap Per cent S	Protected Scrap Per cent S
.035	.031
.034	.027
.026	.03
.037	.03
.039	.027
.039	.027
.032	.03
.032	.29

E. Elimination of Sulphur by Use of $CaCl_2$ with a Limey Slag. See explanation under "Method of Elimination of Sulphur from Pig Iron."

Saniter's process of removing sulphur from steel in basic open hearths is applied to basic open hearths in which sulphury iron and minerals may be used. In order to attain results at an early period after the charge is melted it is necessary to obtain a basic slag of 50 to 60 per cent of lime then adding quantities of $CaCl_2$ to it. Then 200 lbs. of lime stone per ton is added with the charge of scrap and the $CaCl_2$ added at intervals of 50 to 70 lbs. per ton of steel.

TABLE X

Steel Made C	Steel Made Si	Steel Made S	Steel Made P	Steel Made Mn	Average % of S in Metal	No.	Pig Iron Used Si	Pig Iron Used S	Pig Iron Used P	Pig Iron Used Mn
.215	trace	.081	.027	.68	.58	1	.04	.76	1.3	.18
.08	"	.048	.025	.43	.20	4	.04	.25	1.3	.18
.18	"	.018	.034	.40	.18	8	.40	.22	2.5	1.30
.15	"	.038	.040	.58	.13	12	.20	.15	2.6	1.00

Pig used 75%

Note: Better elimination with higher Mn.

F. Elimination of Sulphur by use of CaC (calcium carbide).

In addition of calcium carbide at the end of the process when the carbon is reduced to its required state, the addition of the calcium carbide keeps the bath, which tends to grow cold due to the higher melting point of the iron and carbon alloy which is the steel, from becoming resulphurized. It reduces any FeO which tends to form between the slag and metal, thus no reaction takes place between CaS and FeO.

NEW STEEL MAKING PROCESS

An interesting new steel making process has been put into successful operation at the works of Messrs. Edgar Allen & Company, Ltd., Sheffield, which promises a great revolution in electric steel melting in the near future.

They have installed in those works one 10-ton and one 3½-ton Stobie electric steel melting furnaces which are being worked together as a single unit under the Stobie patent duplex electric process. By this means, scrap steel is electrically melted and refined by oxidation in a continuous manner in the large primary furnace, and a third or more of the molten bath is transferred down a shoot at short intervals to the small secondary furnace for finishing.

The advantages of the process are both electrical and metallurgical.

Electrically, the load factor is greatly increased by the continuous working, and the power factor is much improved by the maintenance of, mainly molten baths. Fluctuations of current are, also, less marked and of shorter duration.

Metallurgically, the main advantage is the frequent supplies of small quantities of steel, of varying compostions if required, at the low cost of operatnig plant of large output. For ingot or foundry work, this advance in practice is of considerable interest.

Additional advantages of the new process over an installation of several furnaces working independently include the less space occupied by the plant; the reduced crane service required; the much reduced repairs to furnace linings for a given output of steel and the freer choice in scrap for melting.

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*Open Hearth Process, H. H. Campbell, A. I. M. E. Vol. 22, page 455.

Gas Producers and Producer Gas

Many Misconceptions Still Exist, Due to Lack of Knowledge of Present Practice—Specifications Covering Producer Design—Comparative Gas Costs, Showing Influence of Increased Rates.

By VICTOR WINDETT*

An executive of a small, but successful, rolling mill gave to the writer his impression of a gas producer as being a box-like thing lined with fire brick, in the top of which one dumped charges of coal at times, worked hard at the clinkers, and shoveled ashes from the bottom, while gas was piped from a hole in the side. This conception suggested the thought to him that any one could run so crude an apparatus. The corollary followed that the lower the wages paid the cheaper the output. To him all was gas as long as it would burn, and Btu. had no significance. This description of a producer comes dangerously near some devices which have been palmed off on the public in recent times, and are still in use in too many plants today. The fundamentally wrong view, underlying this situation has not yet been entirely abandoned.

However as a general thing, a correct appreciation of producer gas and its manufacturer now prevails in most minds. It is important that this is so as the tonnage of coal used in making this gas runs into a very large figure. In a steel works plant containing the usual steel working furnaces, open hearth, annealing, and reheating, over 50 per cent of the coal consumed is charged into gas producers. In the power plants of the mill, where the remainder is used, are found all manner of gauges and measuring devices to economize the coal. We have come to the time when similar guides and checks must be used by the gas house personnel. Some will urge the objection that this means the introduction of high priced labor where now the cheapest labor is found sufficient. The answer is "yes." But the advance per man may be something like 5 cents an hour more, and in a modern gas house properly equipped with the best of recently developed producers, the number of men is reduced so materially that the improved practice shows a saving.

In this connection the question was asked if it would not be worth while to put in the gas house, men of the caliber of say young college graduates, who accustomed to observation of gauges, etc., would watch the gauges and the internal conditions of the producers and make a very superior gas. Such young men would quickly learn to do this, but having mastered the problem would not be willing to stay gasmen very long, if they were really worth while fellows. Where tried, gas making has been learned well and quickly by such young men who have been advanced in position. All that is needed for a good gas man is for him to have a speaking acquaintance with the English language and intelligent enough to be able to read dials of a gauge or pyrometer and associate it with the internal working of the producers.

Vastly more important than the matter of gauges is installation of producers of high efficiency and regularity of operation. It is possible now to buy such a machine of the highest development of the completely mechanical type, at a moderate price, due to the use of the principle of quantity production. This is on account of their being built in groups of several at a time and then shipped from stock.

A thoroughly satisfactory producer should conform to the following requirements:

1. It should gasify cheap low grade coal in practically the condition as shipped from the mine, retaining all of the "fines," and with only a minimum of coarse crushing.
2. It should yield a gas of maximum calorific value, high luminosity and retain the sensible heat imparted to it without loss from contact with unnecessary cooling devices, such as water jackets.
3. It should make a gas abundant in quantity, and at comparatively low temperatures, such as from 900 to 1,250 deg. F.
4. The ash should be open or porous for a free upflow of the air blast. Clinkers should be passed down the ash zone and thence ejected in small fragments. In such shape they are not objectionable, as then they tend to keep the ash zone from being packed with powdery dense ash. Their adhesion to the brick lining should be prevented; this is possible by their being worked down mechanically, without hand barring or hand poking. This is done with the same motion of the producer that keeps the fire in a good gasifying condition.

A plant may be rated as to its capacity in a number of ways. If the capacity is given in tons of coal used per day, it has a certain value, if one knows the size and use of the plant. A better rating is the consumption per producer hour. The best rating is according to the amount of coal gasified per square foot of horizontal cross sectional area of the producer per hour. In some cases it is convenient to consider the volume in cubic feet of gas made per day, or else the heat available measured in Btu. per day.

The progressive development in producer practice in the last 12 or 15 years and the economic advantage of the modern type of producer, which is entirely mechanical, over the older type of stationary hand operated machines may be seen by comparing the data in Table I. In example "A," column 1 refers to an installation, built several years ago but still in service, and doing what is regarded as excellent work. Column 2 gives the operation of producers of the same type as in column 1 but equipped with a form of mechanical top to partially modernize the producers. The cost of the labor per ton of coal used and the rate of gasification shows a gratifying improvement. Column 3 gives the corresponding figures for an early type of mechanical producers which, however, are charged by hand. Even

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*Member of the A. S. C. E. Wellman-Seaver-Morgan Company, Cleveland, Ohio.

TABLE 1

Gas Producer Operation

Example	A				B		
Column	1	2	3	4	5	6	7
Where used	Metallurgical Works				Glass Factory		
Type of Producer	Stationary		Mechanically Operated		Stationary	Mechanically Operated	
Coal Charging	By Hand	Mechanical	By Hand	Mechanical Feed	By Hand	"Mechanical Coal Feed"	
Shell and Ash Pan	Stationary. Ash Pan of Concrete.		Revolving Shell and Ash Pan		Same as Cols. 1-2	Same as Column 4	
Poker	None		Swinging	Oscillating	None	Oscillating	
No. of Producers	14	8	6	3	6	2	1
Producer Cross Section ... Ft.-In.	7'0" x 9'-0"	10'-3" Dia.	10'0" Dia.	8'-0" Dia.	7'0" x 9'0"	8'-0" Dia.	8'-0" Dia.
Producer Cross Section Area ... Sq. Ft.	63.0	82.5	78.54	50.26	63.0	50.26	50.26
Producer Cross Section Total Area ... Sq. Ft.	882.0	660.0	471.24	150.78	378.0	100.52	100.52
Operating Time per Day ... Hrs.	22.0	23.0	22.33	24.0	23.33	24.0	24.0
Lost Time, working fire and clinkers ... Hrs.	2.0	1.0	1.67	0	.67	0.0	0.0
Net Operating Time ... %	92	96	93	100	97.5	100.0	100.0
Coal used per Production-day ... Lbs.	11,400	20,000	26,660	53,300	10,000	30,000	60,000
Coal used per Plant-day ... Lbs.	160,000	160,000	160,000	160,000	60,000	60,000	60,000
Coal used per Plant-day ... Tons	80	80	80	80	30	30	30
Coal used per Gross Production Hour ... Lbs.	475	835	1,060	2,220	417	1,250	2,500
Coal used per Net Production Hour ... Lbs.	520	870	1,155	2,220	428.5	1,250	2,500
Coal used per Gross per sq. ft. per hr. ... Lbs.	7.54	10.1	14.0	44.2	6.6	24.9	49.75
Coal used per Net per sq. ft. per hr. ... Lbs.	8.25	10.6	15.3	44.2	6.8	24.9	49.75
Labor—Three shifts per 24 Hr. Day							
First Gasman	3 @ $4.04 $12.12	3 @ $4.25 $12.75	3 @ $4.25 $12.75	3 @ $4.80 $14.40	1 @ $3.25 $ 3.25	3 @ $4.00 $12.00	3 @ $4.00 $12.00
Second Gasman	21 @ $3.96 83.16	12 @ $3.96 47.52	6 @ $3.96 23.76		9 @ $3.00 27.00		
Ash and Coal Man	In above			1 @ $4.00 4.00	1 @ $2.75 2.75	1 @ $2.75 2.75	1 @ $2.75 2.75
Total ... $	24 $95.28	15 $60.27	9 $36.51	4 $18.40	11 $33.00	4 $14.75	4 $14.75
Labor Cost per Ton of Coal ... $	$ 1.19	$ 0.76	$ 0.46	$ 0.23	$1.10	0.494	0.494
Reduction ... $	.0	$ 0.43	$ 0.73	$ 0.96	.0	0.606	0.606
Coal per Man per Day ... Tons	3.33	5.33	8.88	20.0	2.7	7.5	7.5

Wages — Cols. 1 and 2, actual rates; Col. 5, based on local rates; Cols. 3, 4, 6 and 7, assumed rates.

Producer Conditions—Cols. 1, 2, 3, and 5, based on actual operation except Tons of Coal and No. of Producers are based on tonnage for Cols. 1 and 5. Cols. 4, 6, and 7 based on tons of coal of Cols. 1 and 5, and on actual operation of this type of producer. All rates of coal gasification are normal for the several producers.

with this drawback a still further improvement is had. Column 4 gives the performance of an equivalent plant of the latest development of producers which are entirely mechanical in working and continuous "day in and day out," without the idle times of cleaning fires one or more times a day.

To secure a more equitable comparison the tonnage of coal gasified per 24 hour day is taken the same, and the number of producers is taken to run them at a fair usual rate per hour. In example "B" column 5 represents the practice in a well designed and built plant in the Central West, using a better grade of coal than the other plant. The figure for the weight of coal is that for the present time of writing.

Column 7 shows that one of the new producers is sufficient to displace the old ones, but to provide for a moderate extension of the plant, two are preferred by the management. The rates of labor are approximately those prevailing in the localities in question, except that a higher rate is assumed for the costs in columns 4, 6 and 7, as the great reduction of men required will permit the employment of a better grade of men, whose quality will warrant the increase. It may be added that the rates of combustion of the producers of columns 4, 6 and 7 ranging from 25 pounds to 50 pounds per square foot per hour are well within the proven capacities of this producer working on an average gas coal. It may be added in passing that it is quite undesirable to run a producer at a rate considerably below the designed economical minimum.

Producer gas should have a place in many small plants whose owners are deterred from it on account of the supposed high cost of the plant required. Generally speaking a plant improvement can be financed when an adequate return is reasonably certain. An example of such an installation in a plant of moderate size, was found in a steel casting foundry having a 20-ton open hearth furnace. Fuel oil was given up as a fuel after years of use on account of rising costs.

One mechanical producer with a gas house, overhead and ground coal bins, flues and dust catcher was installed and gas used in the furnace. Included in the charge for coal for the first month's run with gas is the coal used in the previous month in training the gas men, trying out the producer, etc. The gas men were concrete wheelers taken out of the construction gang employed in putting in the producer foundations. In a couple of days' time they were "broken into" the producer tending and readily accustomed themselves to operating the producer according to the indications of the gauges, the pyrometer, the gas condition and the appearance of the ashes. Table II gives a statement of the last two months of oil and the first two months of gas heating of the furnace.

The question arises at times as to the cost of producer gas, especially when it is under consideration for us in a plant of moderate size. Table III is based on gasifying 100.0 tons of coal per day of 24 hours continuous operation. Gas coal of average good quality is assumed. The cost for one day is the basis of the figures.

TABLE II—20-TON OPEN HEARTH FURNACE MELTING FUEL EXPENSE

	Fuel Oil 2 Months	Producer Gas 2 Months
Weight of steel (in the ladle), tons	2,066.00	1,996.00
Fuel oil—144,620 gals. at $0.09	$13,015.80	
West Virginia Gas Coal—998 tons at $7.25		$7,225.00
Steam for spraying oil—42,000 lbs. at $0.50 per M	21.00	
Steam for air blast—687,600 lbs. at $0.05 per M		343.80
Power, running producer—2,500 wkh. at $0.03		75.00
Oil and waste		15.00
Cooling water—54,900 gals. at $0.10 per M		54.00
Mechanical supervision (first month)		75.00
Operating labor, two men, 12 hr. shifts, one off each Sunday, 1,332 hrs. at $0.50		666.00
Depreciation, Repairs and Interest on $35,000.00 at 12% per year		750.00
Total charge for fuel	$13,036.80	$9,203.80
Saving by use of Producer Gas		$3,833.00
Cost per ton of steel in the ladle	$6.31	4.61
Saving per ton of steel in the ladle		1.70
Ratio of cost—producer gas / fuel oil		70.8%

TABLE III—COST OF PRODUCER GAS

Coal delivered to the producer at $8.00 and at $4.00 per ton, respectively, 100 tons daily		$800.00	$400.00
Steam for blast at 600 lbs. per ton of coal 60,000 lbs. at $0.50 per M lbs.		30.00	30.00
Cooling water, 5 gals. per min. 28,000 gals. at $0.07 per 1,000 gals.		1.96	1.98
Power for driving producer 300 kwh. at$.01¼		3.75	3.75
Labor—2 gas men, 1 per 12 hr. shift at $0.65	$15.60		
1 ash man per one 12 hr. shift at $0.40, for one shift only, his time depends upon facilities for ash disposal and removal from the gas house	4.80		
1 coal and ash hoist man, 4 hrs. at $0.70	2.80		
		23.20	23.20
Burden, repairs supplies, etc., at 6% interest and depreciation at 10% on investment of $70,000; one year of 308 days		36.40	36.40
		$895.31	$495.31
Cost per ton of coal		$8,944	$4.944
Cost per 1,000 cu. ft. of gas (160 Btu. low value)		.069	.038
Cost per 1,000,000 Btu		.43	.238

Low Temperatures Prevent Annoyance.

A low gas temperature tends to prevent breaking up of the hydrocarbons in the gas and diminish the amount of soot in the flues. Clogging of flues between the producer and the furnaces in which the gas is used is due to the accumulations of soot, tar and unreduced coal dust; these losses are annoying, and call for the burning out the flues, at the week-end. The economic loss is not as large as their disagreeableness might suggest, if the following report is representative of general practice.

SOOT LOSS

Type of producer	8′ 0″ partly mechanical		
Length of run	1 week of 5½ days of 24 hours		
Coal charged	198,000 lbs.		
Coal dry (3.5% moisture)	191,100 lbs.		
Calorific value (13,860 Btu. dry coal)	2,648,650 Btu.		
Soot analysis: S	1.00%		
Vol.	.18	78.89% Combustible	3,630 lbs.
Fixed C	78.71		
H_2O	.77		
Ash	17.34		
Btu. per lb.	11,500		
Calorific value of soot	41,745,000 Btu.		
Rate of loss due to soot (ratio of calorific values)	1.57%		

The calorific value of gas is generally calculated from the chemical analysis. In the accepted method of taking the gas sample and in the laboratory work of making the analysis itself the tar vapor in the gas is washed out by the aqueous solutions of the reagents employed and lost and they do not appear in the chemist's report, but in the actual burning of the gas in the furnace they are utilized. These vapors add considerably to the heating of the furnace as they burn with a luminous flame.

Selection of Producer Fuels.

The choice of fuel for a producer is determined to a certain extent by the use to be made of the resulting gas. Iron and steel working furnaces and also those for white ceramic work require a low sulphur gas. According to prevailing practice, the melter in charge of open hearth furnaces is accustomed to judge his furnace conditions and temperatures largely by the appearance of the flame of the burning gas in passing through the furnace chamber. He requires a luminous flame, though he may be trained to use a less luminous one in time. In burning brick, an important part of the process is the preliminary driving off of the moisture of the freshly charged brick in the kiln. This calls for a dry gas and one in which the hydrogen content should be low and burning with a long flame.

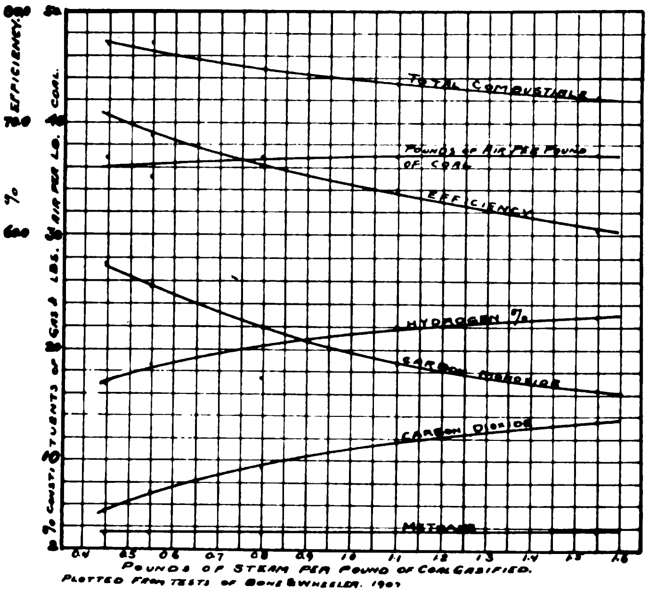

Diagram 1—Influence of steam in the air blast.

In all producer operation, a coal of moderate size should be used. One strong objection to hand hopper feeding is the use of large lumps. It is probable that the coal in such cases is not completely consumed in the center of large lumps, and one cause of the high carbon content of the ash in this style of producer is due to the manner of feeding, where lumps as large as the hand hopper will admit are used. On the other hand, the use of a coal running excessively high in fine dust results in some of the finer particles of this dust being carried by the strea mof gas up into the flues. Therefore, irrespective of the type of producer, the best results are obtainable with a coal of moderately uniform size and carrying as little dust as is commercially possible and of a reasonably fair quality. However, the final condition to be satisfied is a financial one and the ease of obtaining a continuous supply of a workable gas coal.

The purchaser of a producer must be provided with a piece of apparatus, which will enable him to buy cheap coal delivered to the producer in the condition as shipped from the mine as nearly as possible. The complete mechanical producer with its mechanical feed is best fitted for the use of such fuel. It does not call for crushing under 4-in. lumps and may carry fines as high as 35 per cent in a fair coal without serious disadvantage unless running high in pyrites and sulphur. One reason for the very high percentage of combustible in the ashes of hand operated producer is that they require a breaking down of the clinkers and hand working of the fire at regular intervals at times as close as four hours apart. The uplift and down thrust of the hand bar thus used causes a violent disturbance of the fire and an actual driving down into the ashes of considerable unconsumed carbon which is lost in the ashes. Published operating records show with hand operated producers a waste of carbon in the ash rising as high as 35.8 per cent of the ash weight. This is with coals running about 11.5 per cent ash.

Feeding the coal in a practically continuous small stream onto the surface of the fuel bed avoids the periodic violent flunctuations of gas from an over rich hydrocarbon immediately after dumping a charge, down to a thin lean gas as is found in hand hopper practice.

A desirable gas coal is a bituminous coal of the following analysis:

Volatile matter	30 to 40%
Fixed carbon	50 to 60%
Sulphur (in the above)	Not over 1.5%
Ash	Under 15%
Fusing temperature of the ash	Over 2200 deg. Fahr.
Size	Passing through a 4" ring
Fines	Not over 35%

Owing to local conditions, a very inferior coal may be used in the producer. A coal of the following analysis has been run at as high a rate as 50 lbs. per sq. ft. per hour:

Volatile matter	34.25%
Fixed carbon	38.25
Sulphur (in above)..............	8.28
Moisture as charged to producer	8.20
Ash	19.30
Fusing temperature of the ash....	2,072° F.

That such a coal has been run continuously through a mechanical producer with but 4.05 per cent carbon in ash is ample evidence, to those familiar with gas producer operation, that such coal may be successfully used in a producer. Due to the high ash and sulphur content and physical characteristics of the coal, it was necessary to work this with a heavy excess of steam and a very small supply of air in the blast. The large moisture content of coal 8.2 made an objectionably wet gas, as this moisture carried into a producer by the coal is vaporized and passes into the gas without being dissociated and assisting in forming either hydrocarbons or carbon-monoxide.

Diagram I, "Influence of Steam in the Air Blast," is derived from data published by Bone & Wheeler in the Journal of the Steel and Iron Institute, vol. 73, page 12, in 1907. Diagram 2, "Influence of Blast Saturation Temperature on the Air Blast," is plotted from data of tests made during the present year in Cleveland, Ohio. Both diagrams point to the conclusion that the use of steam in the air blast should be restricted to a minimum. The limiting condition being the clinkering nature of the coal. Large amounts in the blast are detrimental to the quality of the gas.

The steam jet blower has the merit of simplicity and cheapness of cost. Like the steam siphon or the injector, its efficiency as an air pump is probably as low as the siphon is for a water pump. An increase in output is had only at the expense of a vastly larger increase of steam. The steam turbine direct connected air blower, not only runs with a lesser consumption of steam, but is susceptible of separate regulation of both air and steam. The humidity of the air may be changed instantly from zero to a large degree of supersaturation without varying the air and vice versa. With certain coals of a high sulphur and ash content, and contaminated with pyrites, there has not been sufficient experience with the "turbo" blower as it stands for the present. The producer operation during which the observations were made for diagram No. 2 was with a turbo blower.

High Gas Temperatures Should Be Avoided.

The thermochemical efficiency of a producer is affected by the physical and chemical qualities of the coal used, by the proportions and amounts of air and steam of the air blast, and especially by the characteristics of the producer itself. The better the design of the latter and the simpler its operation the better are the results produced.

In the normal running of a producer, a low gas temperature gives the best results. When a gas temperature of 1,700 or 1,800 deg. F. is found, it is generally secured at the expense of burning gas in the producer which superheats the gas and dilutes it with CO_2 which is produced from the CO. This operation should be performed in the furnace itself and not in the producer. Such temperatures are unnecessary and should not be permitted. A satisfactory gas temperature should be between 900 deg. and 1,250 deg. F.

Losses Caused By Cooling.

The loss in cooling the gas when passing through a cleaning process is a variable quantity depending on the initial and final gas temperatures and the composition of the coal and the gas itself. When figured on the basis of the weight of coal charged, this is a positive loss as shown in the following table. The final washed gas temperature is taken at 120 deg. F.

Initial Temperature of Gas	Loss of Heat by Washing
1800°	19.3%
1600°	17.0
1400°	14.8
1200°	12.5
1000°	10.2

The advantage of washing and cleaning producer gas is the ability to pipe the gas to considerable distance, and also on account of its being cooled and occupying a smaller volume, the use of smaller pipes or flues is permissible. The reduction in volume in cooling a gas from 1,200 deg. to 120 deg. is about 70 per cent. It is rarely that the saving for capital investment thus accomplished will balance the ever continuing waste of energy entailed in using clean gas, unless the gas pipes are of great length.

To this loss of sensible heat in cleaning gas should be added the operating cost and capital charges for the cleaning plant.

Rates of Operation Greatly Increased.

We find in the various treatises on producers statements regarding the rate of gasification such as appears in Latta's "American Producer Gas Practice," page 30, edition 1910: "10 lbs. per sq. ft. of grate surface is usually an ample allowance." In Fernald and Orrok's excellent "Engineering of Power Plants," edition of 1916, average rates of combustion of 8.5 lbs. up to 14.0 lbs. per square foot per hour are given, the 14.0 lbs. being a maximum.

In 1919 a well known mechanical producer in ordinary mill operation was run at 37.0 lbs. per square foot per hour. The present year has seen this rate raised to 50.0 lbs. per hour for continuous ordinary operation in a producer running on a reasonably fair gas coal, the producer being entirely mechanical in its working, which is maintained at a rate proportional to the demand for gas. That this is not accompanied by a production of poor gas is shown by the following analyses of gas using the continuous method of sampling:

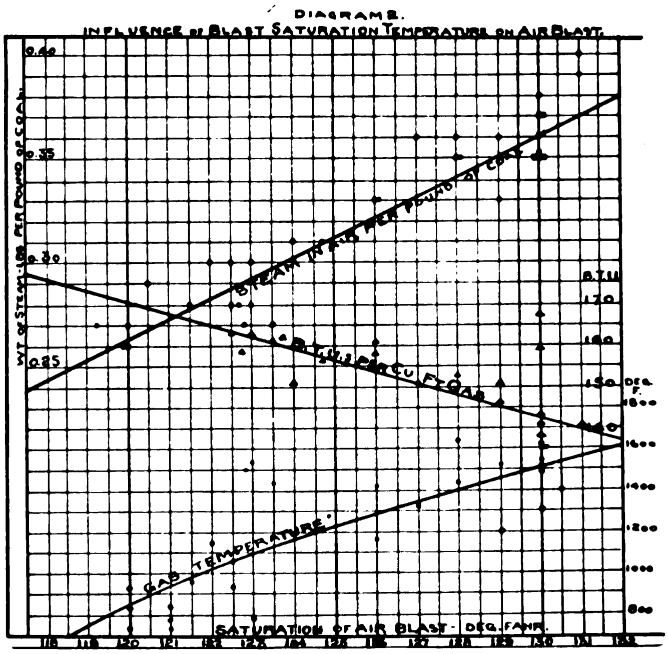

Diagram 2—Influence of blast saturation temperature on air blast.

CO	26.7%	Combustible 44.1%	Calorific Value of Gas
CH_4	3.1		
C_2H_4	.4		
H_2	13.9		Gross 168.5 Btu.
CO_2	4.3	Noncombustible 55.0%	Net 161.0 Btu.
O_2	0.1		
N_2	51.5		

It is apparent from the low rates given by the above authorities that the economic progress of producer practice is as great as the technical advance in design and operation. The best obtainable producer working at the now possible high rate of output as compared with the older machines reduces the capital investment, the area of land occupied, the labor employed and the cost of the gas produced. It eliminates shut down periods for cleaning fires and ash zones. The reliable continuous gasification of low grade coal is possible.

Net Value Is Gross Value.

The United States Steel Corporation, through the action of its Chemists' Committee, headed by J. N. Camp, has adopted for its standard the continuous method of sampling gas rather than that of momentary sampling. It uses the net calorific value of the gas at 62 deg. F. instead of the gross value at 32 deg. which latter figures do not represent the conditions of mill operations. This is a desirable situation and is more in the direction of a correct appreciation of the conditions of making and using gas rather than the gross value at 32 deg. which may, however, be of use in some theoretical studies in the laboratory. It is to be hoped that the lead taken by the steel corporation will be accepted and followed by all chemists and combustion engineers, so as to avoid confusion and incorrect impressions on the part of those not entirely familiar with the difference between these two values of gas.

Individual tests or analyses of coal, gas and the resulting ashes found in producer operation are of little practical value and may be quite misleading. A true representative sample of the gas can only be secured by taking a continuous sample extending over several hours of operation. Where momentary samples are made, one can secure from the same producer and same coal, a gas of very high calorific value or exceedingly low value depending upon whether the sample was taken just after charging in a hopper full of coal or just before this operation. In the case of the continuous mechanical feeds, this liability of the error is not so large.

Operating Characteristics Shown By Tests.

Producer operation is accompanied by the same characteristics as are found in the generation of steam in a boiler. That is within the range of the capacity of the apparatus there is a certain variation in the quality of the output proportional to the rate of operation. Within the extreme rates is found an economical range at which the producer may be used with but little change in the calorific quality of the gas. Above and below this practical operating range, the calorific value of the gas becomes too low or else the quantity of gas delivered is inadequate.

To study the performance of the producer or the gasification of a coal, a number of tests should be made of sufficient duration to develop a uniformity of operation. These tests should be made at minimum and maximum possible rates, together with several intermediate tests (the more the better) although four observations made wtih accuracy will determine the curve of performance. The observed calorific value of the gas should be plotted according to the rate of coal consumption and a smooth curve best fitting these points should be drawn. Or better still, the equation of the curve should be calculated as this is a simple arithmetical process and then plotted. The reliability of the tests and their results are indubitably fixed by their closeness to the curve. Tests widely diverted from the curve should be rejected as containing errors of observation which render them valueless. Those lying on or near to the curve are given thereby a sure warranty of their validity or reliability.

As an example, a series of producer tests were made on a certain coal from which the equation of the curve was deduced in the following tow forms:

$$(1)\quad \text{Calorific value or Btu. per cu. ft. of gas} = \frac{182.0}{1 + 0.0043 \times \text{lbs. coal per sq. ft. per hr.}}$$

$$(2)\quad \text{Log. Btu. per cu. ft. of gas} = 2.2511 - 0.0016 \times \text{ibs. coal per sq. ft. per hr.}$$

The index of accuracy is that the sum of the squares of the variations between the test figures and the calculated values must be less than that obtained from any other curves which may be drawn. In the case above mentioned, the sum of the squares thus indicated for equation (1) was 9 per cent smaller than the corresponding figure obtained from a smooth curve drawn by hand using a ship curve, from which equation (2) was calculated.

Having plotted the calorific value of the coal as determined by test and curve as calculated, a more perfect knowledge of the coal or producer performance will be had by plotting separate curves for the several constituents of the gas, the saturation temperature of the blast, the weight of steam used per pound of coal, the steam, air blast and gas discharge temperatures and pressures, total weight of coal charged per producer hour, the percentage of combustible in the ash and the cubic feet of gas made per pound of coal. These, if plotted all on one sheet, will give a complete story of the operations.

Logarithmic paper will be found especially advantageous for this work.

Test Results from Modern Producer.

In closing, an example of a test made on a modern complete mechanical gas producer is given to illustrate some of the features of this discussion, although it is not a maximum test either in rate of gasification or quality of gas produced.

Producer operation, hours	6 P. M. 12.0 6 A. M.
Dry coal gasified, lbs.	29,070
Dry coal gasified per hour, lbs.	2,420
Dry coal gasified per sq. ft., lbs.	48.2
Feed operation, hours	12
Dry coal fed, lbs.	29,070
Dry coal per hour feed .operation, lbs.	2,420
Plow operation, hours	12.0
Power input to motor 240 volts, amp.	4.5
Power input to motor 240 volts, hp.	1.45
Steam press to turbo, lbs.	55.0
Blast pressure to producer, inches of water	5.0
Blast temperature, deg. F.	124.7
Atmospheric temperature, deg. F.	
Atmospheric relative humidity, per cent	
Steam in blast per lb. of gasified coal, lb.	0.31
Gas temperature, deg. F.	1,290
Fire condition	Good
Gas condition	Good
From observation hole top to top of coal, in.	32½
Coal thickness, in.	9
Fire thickness, in.	11
To blast hood base, in.	18
Cooling inflow water, temperature deg. F.	95
Cooling outflow water, temperature deg. F.	145
Water, per minute, gals.	7.5
Gas analysis. Volumetric. Continuous 12-hour sample.	
Carbon monoxide Co., per cent	25.5
Methane, CH_4, per cent	2.9
Ethylene C_2H_4, per cent	0.5
Hydrogen H_2, per cent	13.8
Total combustibles, per cent	42.7
Carbon dioxide CO_2, per cent	4.6
Oxygen O_2, per cent	0.1
Uitrogen N_2, per cent	52.6
Total incombustibles, per cent	57.3
Heat of combustion, 1 cu. ft. gas "Low" U. S. S. Corporation, Btu.	155.6
Heat of combustion 1 cu. ft. gas "High" American Society Mechanical Engineers, Btu.	163.2

Calorific values of gas figured as below:

	U. S. Steel Corp. Low at 62 Deg. F.	Am. Soc. Mech. Engrs. High at 60 Deg. F
CO	332 Btu.	319 Btu.
CH_4	909 "	1,002 "
C_2H_4	1,495 "	1,595 "
H_2	274 "	330 "

The "low" values at 62 deg. F. more nearly represent operating mill conditions.

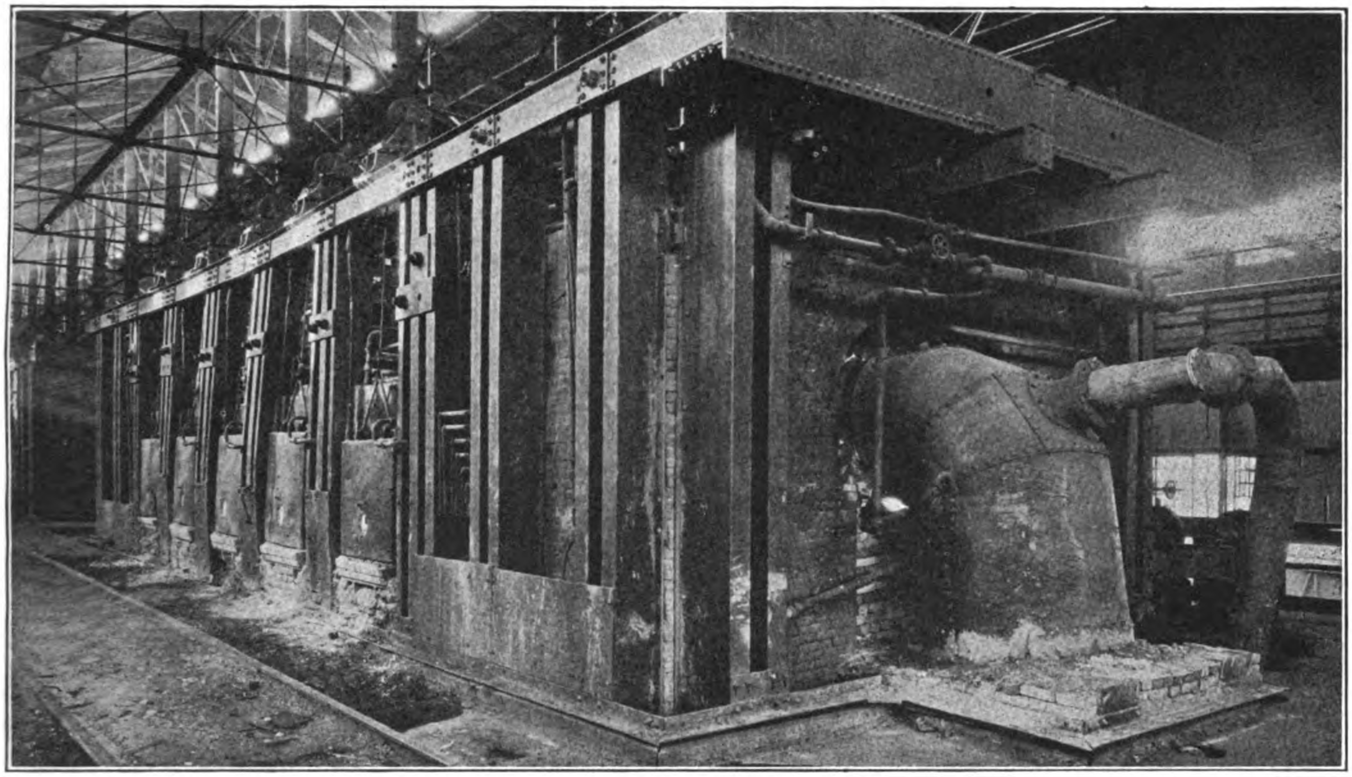

Fig. 1—In the Loftus furnace the dog house is replaced by a stream line pipe construction which is readily movable in any direction. Regenerated air is introduced under pressure through the smaller pipe to aid in thoroughly mixing and in fixing the direction of the gas entry.

Improvements in Open Hearth Furnaces

Description of the Loftus Variable Pressure Method of Firing Open Hearth Furnaces and Brief Explanation of the Naismith Mechanical Neutral Joint.

By E. C. COOK*

THE importance of the basic open hearth process in the development of the steel industry can be measured by its tremendous growth over the relatively short period during which it has been practiced. Its growth has been due to the fact that it has permitted the use of iron of any phosphorus content, thus making available vast deposits of ore which might not otherwise be utilized. Extreme flexibility is possible, due to the various methods devised for its application and the process allows for the production of steel in great variety by variations in the method of manipulation. These variations permit the working of the process economically in regard to the supply of scrap, pig iron and the physical and chemical qualities of the same.

The open hearth furnace in which this process has been carried out has been neglected. It has been stated by some of the most widely known operating men that the present class of furnace is not a success economically or metallurgically. Economically, it is a heat waster and a man waster. Metallurgically, its life is short and the demand for tonnage so insistent that the superintendent is frequently compelled to make certain grades of steel in a furnace which should undergo repair. It has been further stated that the usual period of high efficiency in the present type of furnace represents not more than 60 per cent of the furnace campaign. To meet present day requirements for better fuel economy, increased life of the furnace and shorter melting and refining time, numerous modifications in the design and operation in common use, are necessary. In recent years a number of changes have been proposed and tried out singly and in combination, which have met with varying degrees of success. The most recent of such developments is the Loftus system of introducing regenerated air at variable pressures into the producer gas line, which mixture is discharged through a restricted nozzle into the mixing chamber, thereby inducing the additional regenerated air necessary for combustion. These modifications have been developd by Loftus and are being commercialized by the Vulcan Furnace Company, Pittsburgh, Pa.

Naismith Slag Zone Epuiqment.

The Naismith Indestructo slag zone and mechanical

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*Managing Editor.

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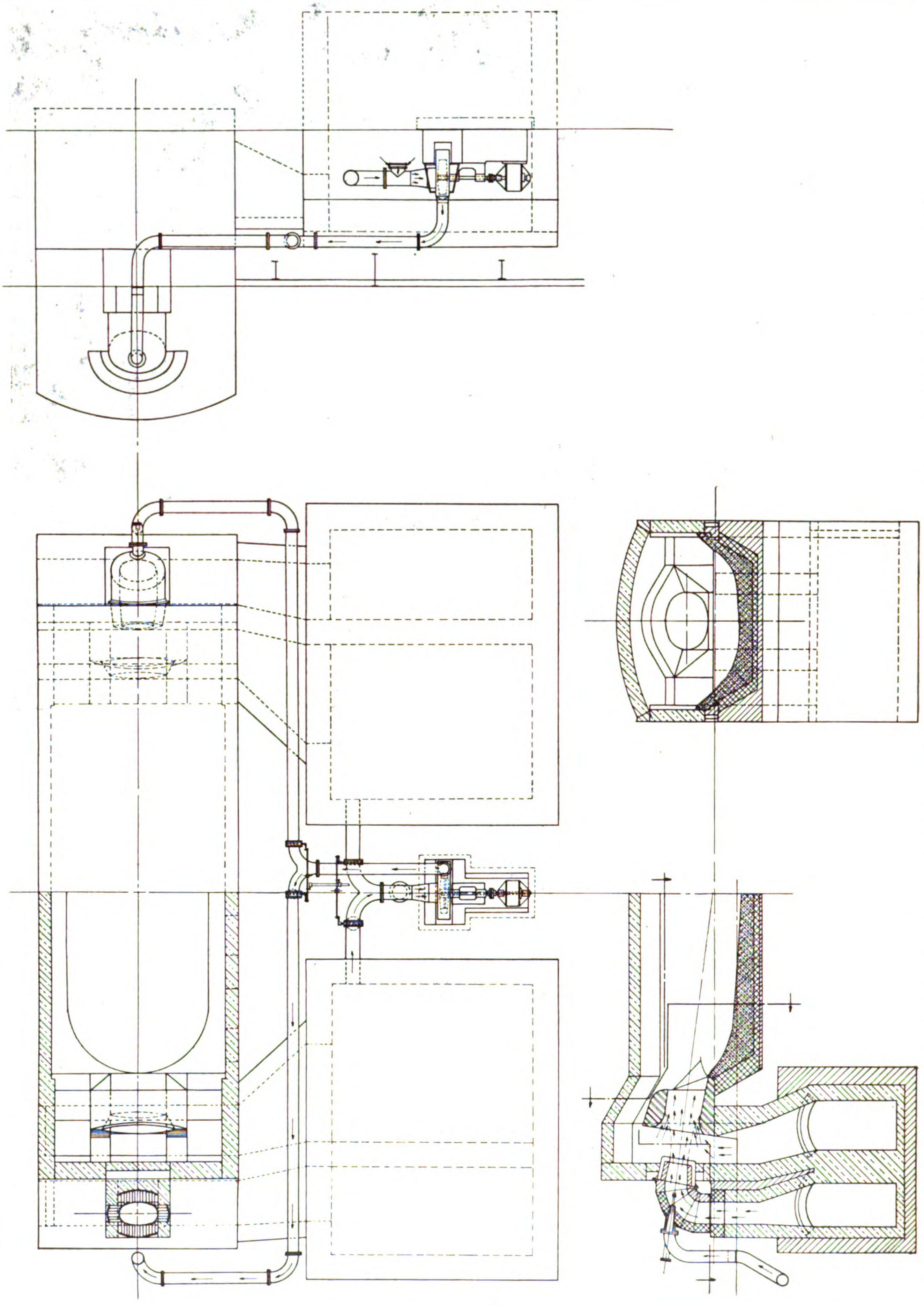

Fig. 3—Showing the piping and general plan used in equipping a furnace for operation according to the Loftus scheme.

neutral joint equipment, which may be seen in the cross section of the furnace shown in Fig. 3, consists of a ⅜-in. steel plate construction through which cooling water previously used on the furnace is circulated. This device is located between the acid and basic linings of the furnace near the banks, replacing the old chrome joint and all magnesite brick at the slag zone; also reinforcing the walls and affording protection for the banks at this point. The equipment provides a foundation upon which to build the acid walls. The skew back channels are suspended by means of hanger bolts, and in this way provides a means for yieldably suspending the roof so as to permit the acid walls to expand upward thereby preventing disruption and bulging of the walls due to the strains and stresses set up by expansion.

The Naismith equipment is manufactured by the Open Hearth Steel Furnace Company, Pittsburgh, who state many advantages and savings are secured through its use. No additional water is required for cooling the front or back walls as it reuses water from other water-cooled equipment on the furnace. The protection afforded permits an increased number of heats, with excessive banking and repairing eliminated. As no magnesite brick are used at the joint, this expensive item of installation and repair is eliminated. A further advantage is claimed from the fact that the furnace can be operated with thinner walls, thus increasing the capacity while at the same time a substantial foundation is provided for rebuilding side walls.

Description of Loftus Open Hearth Furnace.

Access of the air to the gas before entering the furnace chamber is dependent in the usual present design of open hearth furnaces upon inclination of the air port and the gas ports and the extension of the end of the air port to the end of the gas port. The present port areas are usually a compromise to suit conditions of entering and departing gases and the tendency is almost universal to make the area of the ports too large to give the proper mixture for the incoming air and gas and too small for the outgoing products of combustion. In the producer gas furnace the velocity of the gas is far greater than that of the air through its ports, thus creating a condition which will not permit rapid combustion and high flame temperature as the air must overtake the gas before combustion occurs. Delayed and improper combustion develops as a result of this condition, causing the flame to start too far from the entry port and in many cases it is still burning when it passes through the outgoing ports and at times even enters the regenerator chambers. In this way, the brickwork of the furnace is destroyed and the campaign is shortened.

The Loftus furnace shown in Figs. 1, 2 and 3 is designed to remedy these difficulties and, in addition, to afford the operator control over the quality, intensity and length of the flame. Fig. 3 shows a producer gas furnace wherein the producer gas is discharged from a restricted nozzle into the mixing chamber, thereby inducing the necessary air for combustion. A booster supply of regenerated air is withdrawn from the regenerative chamber and passed through a special blower driven by a variable speed motor and introduced into the center of a stream of gas in the direction of its flow through the furnace. The pressure and volume of this booster supply of regenerated air are governed by the variable speed motor.

With this type of furnace construction a thorough mixing of the air with the gas in the hot mixing chamber is effected. An inner core of regenerated air is surrounded by an angular ring of gas. In passing through the mixing chamber this stream surrounds itself with an outer envelope of air. This mixture is discharged from the mixing chamber in the form of a flame, having practically no stratification and with the utmost compactness and continuity of direction. The ready regulation of the pressure and volume of the booster supply of regenerated air permits the operator to control the flame. If he so chooses he may melt down a charge with a short hot flame and refine with a long mellow flame, which completely covers the bath but is not permitted to extend through the outgoing channels.

The old type of gas uptake with its abrupt turn has been replaced by a stream line elbow or gooseneck which is supported in such a way that it may be readily adjusted in all directions. In this way the travel of the gas may be altered to suit conditions after the furnace has been put in operation. In former constructions if one were unfortunate enough to miscalculate the proper angle and pitch of the gas port it was necessary to wait until the furnace was down for the next major repair which was naturally hastened by the destructive action of flame before this condition could be remedied. The stream line feature decreases the erosion of that portion of the uptake corresponding to the bulkhead of the present type of furnace, and affords a construction which may be replaced in about 20 minutes with a spare. The change is made durning the burn-out period.

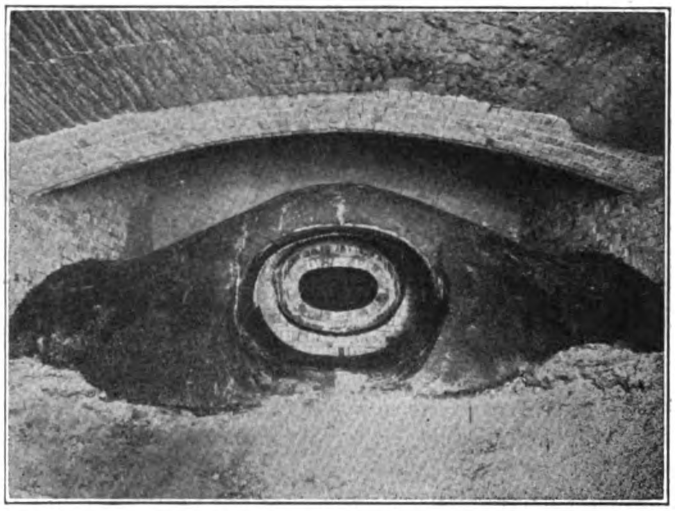

Fig. 2—Showing port construction used with the Loftus system. It is essential that it be water-cooled if the port is to be kept in good condition, although it is stated that it can be operated without the arch.

At the outgoing end of the hearth, the products of combustion together with the gases which arise from the bath of steel are collected through the mixing chamber and the auxiliary channel over the top of the same. Owing to the inherent features of the design, this auxiliary channel is practically inoperative on the incoming end while it provides over three times the area for the outgoing gases over the area of the incoming air and gas. This reduces the velocity of the outgoing gases practically one-third. The auxiliary channels on the incoming end permits a slight infiltration of air which protects the side walls and roof from the intensely hot flame produced by the blow pipe action of this type of furnace The extremely good direction of the flame together with this feature is valuable in increasing the life of the side walls and roof.

The special blower previously referred to withdraws air from the incoming regenerator through an intake pipe in which is located at the blower a mixing valve which admits sufficient air to reduce the temperature to 1,000 deg. F. or less. This precaution is taken in order that the blower may not be injured by excessive temperatures The flow of preheated blast air to either end of the furnace is controlled by four cast iron slide gates. Two of these gates are on the intake line and two on the discharge line. All are operated by one lever located near the reversing and operating control for the furnace. The regulator for controlling the speed of the motor is located on the charging floor near the furnace controls; all of which facilitates the operating of the furnace. A motor and special blower have been in continuous operation for six months in this service. At the present time they are performing their special functions with apparent ease, requiring no attention other than the usual inspection and oiling.

The Vulcan Furnace Company states that it has had a furnace operating on producer gas at one of the independent steel plants since June 8, and during the time of operation they have made consistent gains and improvements in tonnage and furnace campaign.

Can Be Used with Other Fuels or Combination of Fuels.

If it is desired, other fuels or combinations of fuels can be used with this construction. Natural gas can be introduced into the branch located on the blast pipe shown in Fig. 1. In this particular case the additional volume of regenerated air required for burning natural gas is taken from the gas regenerator.

The Greaves-Etchell Electric Furnace for Steel Making*

By DR. ALFRED STANSFIELD†

THIS furnace was introduced in 1915 by two Sheffield inventors, H. A. Greaves, formerly of the Sheffield Corporation Electric Supply Department, and H. Etchells, B.Met. It is controlled in England by T. H. Watson & Company, Lancaster St., Sheffield; in the United States by the Electric Furnace Construction Company, Philadelphia; in Canada by the General Combustion Company, Montreal; in France by Schneider & Company, La Creusot; and in Spain by Sociedad Espanola de Construccion Naval.

The Greaves-Etchells furnace is placed by the writer in the "electrode-hearth" class‡, that is to say it has an electrically conductive hearth which operates as an electrode in that it serves to lead the electric current in or out of the furnace. The furnace has two electrodes, entering through the roof, and a specially designed three-phase electrical supply is connected to the two-top electrodes and the electrode hearth. Larger furnaces have four top electrodes and a hearth connection, and in all recently installed furnaces, having four or more top electrodes, provision is made for disconnecting the hearth contact and supplying the whole of the power through the top electrode, the change in connections being easily effected by means of an oil switch. This arrangement, moreover, provides a high voltage when the supply is all through the top electrode, which is suitable when melting a charge or when starting with a cold furnace, while the lower voltage provided when the bottom contact is used, is more suitable for refining or superheating the steel.

The general arrangement of this furnace is shown in Fig. 1, in which *D* and *E* are the electrodes and *H* is a sheet of copper beneath the lining of the hearth. The three terminals, *D*, *E* and *H*, are connected to the legs *A*, *B* and *C* of a star-connected transformer system, the primary windings being in delta. If the electrical resistance of the hearth were equal to the resistance of each of the electric arcs, the terminals *D*, *E* and *H* could be supplied from an ordinary three-phase source of supply, the voltages between *D* and *E*, *E* and *H*, *H* and *D*, would all be equal and the molten metal *F* would be the neutral point of this system. As however the hearth-resistance is in practice decidedly less than the resistance of an arc, an ordinary three-phase supply cannot be used, and in order to obtain a balanced load on the supply lines the secondary winding, *OC*, must have a smaller voltage than *AO* or *OB*.

The hearth is basic, being made of burned magnesite and dolomite. This material is a non-conductor when cold, but becomes electrically conductive at furnace temperatures, and is therefore likely to have a higher resistance near the outer shell than near the molten metal. It is desirable, however, that the resistance, and hence the production of heat, should be greater near the molten steel than near the outer shell, and precautions are taken to arrive at this condition which is the reverse of what would otherwise be found; the hearth is constructed as follows:

Cables from the terminal *C* make contact with a copper plate *H* fastened inside the steel shell of the furnace. On the copper plate is rammed a layer of graphite mixed with hot tar, this layer being 2 in. thick in the middle and tapering away towards the ends of the plate. Upon this is rammed a 4-in. layer of amorphous carbon mixed with hot tar. The regular lining material, consisting of burned dolomite and magnesite mixed with hot tar, is rammed in on top of the carbon layer and is made at least 24 in. thick. A bed of coke placed on the hearth is made red-hot by means of the electrodes, and this serves to bake the hearth, driving off the volatile part of the tar and heating the hearth until it becomes conducting, when the electric current begins to pass through it and thus aids in completing the baking. The layers of graphite and carbon insure good conductivity of the lowest 6 in. of the lining and above that the basic lining will contain some carbon from the tar, which will aid its conductivity at moderate temperatures, even if no carbon is added in the mixture. The baking should be done carefully and requires from 36 to 50 hours. If the ramming has been uniform the hearth quickly becomes conducting and when the current has once passed, there is no difficulty in starting it again if the lining is kept free from slag.

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*From advance sheets of Dr. Stansfield's new book, "The Electric Furnace for Iron and Steel," which will be published by the McGraw-Hill Book Company.

†Professor of Metallurgy, McGill University, Montreal, Canada.

‡The makers call it an "arc-resistance" furnace. The term is used by some writers for all furnaces, including the Heroult, in which an arc is produced between an electrode and the metal in the furnace. Moreover, the term could be correctly applied to every kind of arc furnace, as the electrodes supply resistance. It will be seen, then, that the term "electrode-hearth," used by the writer, is more explanatory as applied to the Greaves-Etchells furnace.

*The author is indebted for the illustrations and some of the information about Greaves-Etchells furnaces to Frank D. Hodson, president of the Electric Furnace Construction Company.

Furnaces from 500-lb. to 3-ton capacity are usually provided with two electrodes, as is shown in the elevation and left-hand plan of Fig. 1, but furnaces of 3 to 40-ton capacity are provided with four electrodes as shown in Fig. 3, and in the right-hand plan of Fig. 1. For these furnaces there are two independent banks of transformers, each bank being connected to two electrodes and the bottom contact as in Fig. 1, the furnace having thus two separate electrical supplies. In the right-hand plan of this figure, electrodes 1 and 2 are supplied from one bank of transformers and electrodes 3 and 4 from the other. The larger furnaces may be round, or square as in Fig. 2. The electrodes are supported by masts which are spaced around the furnace as shown in that figure, and are tied together by framework above the furnace. The jib arm, carrying the electrode-holder, was lifted and lowered by a vertical screw in the middle of the mast, which was driven by gearing from the electrode-motor as is shown in Fig. 2, but in more recent furnaces, the jib arm is lifted by a cable which passes around sheaves on the jib and the top of the mast and passes down to a winding drum mounted on the mast, as shown in Fig. 3. The method of supporting the jib is shown clearly in both figures.

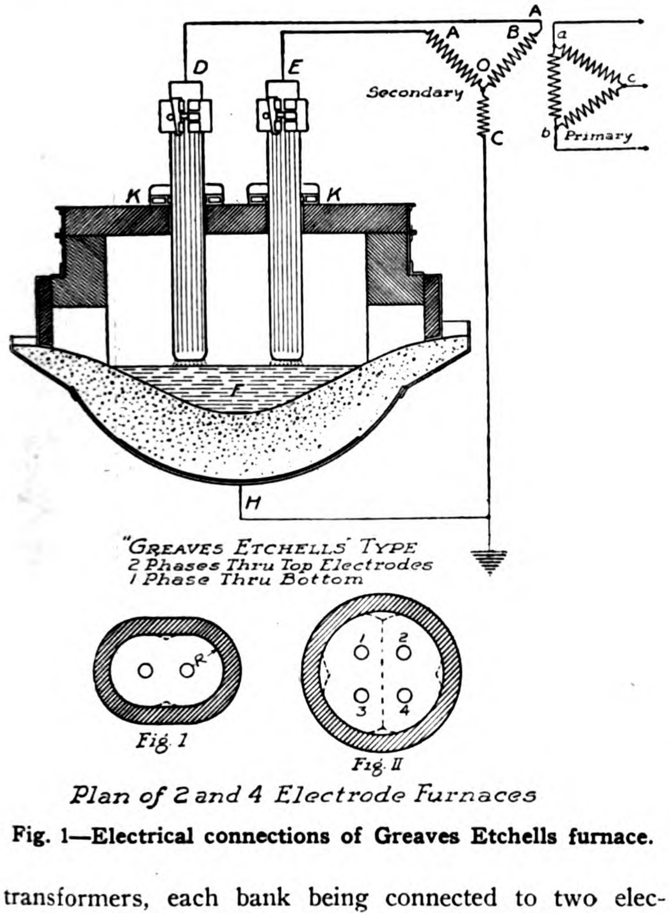

Fig. 1—Electrical connections of Greaves Etchells furnace.

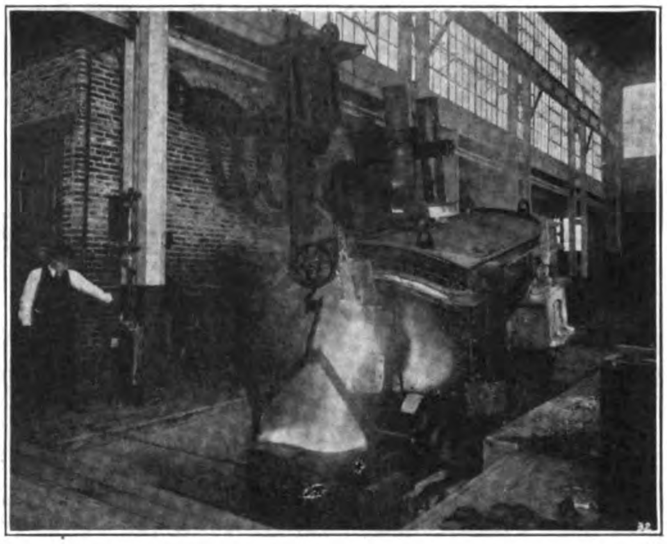

Fig. 2—Six-ton Greaves Etchells furnace.

Fig. 2 shows a 6-ton furnace used for melting and refining steel scrap. Two of the electrode-masts are near together at the back of the furnace, while the other two are at the sides and near the front. The furnace is square in plan, with a simple arched roof on which can be seen the electrode coolers or economizers. The construction of the electrode-holders and supporting arms has already been described. Electrical connections from the right-hand pair of electrodes and from the hearth-contact are made by flexible cables which can be seen passing through the wall to the bank of transformers. Similar connections are made for the other pairs of electrodes. In front of the furnace is a movable platform which can be removed to make room for the ladle.

The furnace is mounted on rockers to pour, and is arranged to have its center of gravity a little below the center of radius of the rocker, so that a small power is sufficient to tilt the furnace, and it would return to its normal position if the mechanism were to break. Tilting is effected by an electric motor, which is placed for safety at a distance from the furnace. The tilting screw and nut are placed in an enclosed oil bath and are carefully protected from dirt, so that very little power is needed to tilt the furnace.

The electrode-holder consists of a steel ring which carries the weight of the electrode and a flexible strap built up of metal links which holds the electrode and makes electrical contact with it as shown in Fig. 2. The contact obtained in this way is so good that there is no need of water-cooling in the holder. The clamp shown in Fig. 2 is tightened by a wedge, as shown in Fig. 1, and this can be loosened or tightened by a light blow from a hammer. Water-cooled collars of a special design are placed around the electrodes at the point where they enter the roof of the furnace. These collars, or "economizers" as they are termed, Fig. 4, are intended to make

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a close joint around the electrodes so as to prevent as far as possible the escape of gases from the furnace. Leakage of gas around the electrodes causes loss of heat, as an equivalent amount of cold air must enter the furnace at the doors, it also causes waste of the electrodes which are burnt by the incoming air, and in addition to this the gas burns where it escapes, heats the electrodes at this point and causes them to waste away before they enter the furnace. The ordinary type of water-cooled collar checks to some extent the escape of gas, but the gas is still hot enough to ignite and burn around the electrode. The Greaves-Etchells "economizers" check the flow of gas at these points and also cool it to such an extent that it does not burn. The makers state that these economizers have been in use for more than two years and show a saving of from 20 to 50 per cent in electrode consumption as compared with furnaces using the ordinary cooling collars. They state that in a basic-lined furnace, with two changes of slag, the consumption averages 9 or 10 lbs. of graphite electrodes or 15 to 18 lbs. of amorphous electrodes per ton of steel.

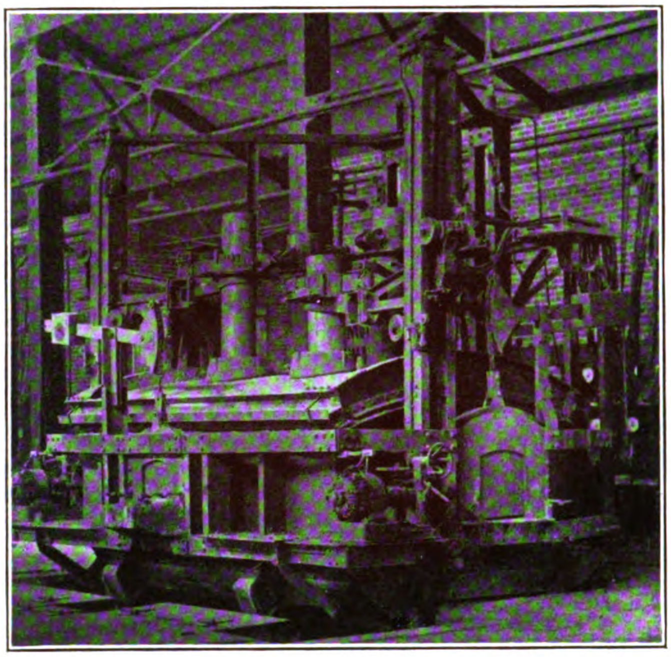

Fig. 3—Showing cable hoist and new type electrode holder and electrode economizer.

Electrical Considerations.

The standard sizes of Greaves-Etchells furnaces run from 500-lb. to 60-ton capacity. The transformer capacity for these is not now standardized, as each installation has been found to have special features, but it varies from about 450 kva. per ton for small furnaces to 200 kva. per ton for very large furnaces. If rapid melting is required, the transfomer capacity is increased. The power-factor averages 88 to 90 per cent while melting and 94 to 96 per cent while refining.

The voltage between the top electrodes *D* and *E*, Fig. 1, is 110 volts, and between one electrode and the bottom plate *H* is 81. These figures correspond to transformer voltages *AO* or about 65 volts and *CO* about 28 volts. These voltages are in use during the melting period; when the charge has melted the voltage is lowered by means of taps on the transformer, and during the refining period the voltage is 84 between the electrodes and 58 between one electrode and the bottom-contact; this is about 76 per cent of the preceding figures and corresponds with transformer voltages of about 50 and 21.

It might be supposed that the molten metal *F* in the furnace would correspond in potential with the neutral point *O* in the transformer system. This need not be the case, however, and it can be shown that in order to obtain a balanced load the voltage between *F* and *H* must be decidedly lower than the voltage of the transformer *OC*. It has been stated that the working voltage *FH* is between 4 and 10 volts during the melting period. This voltage can be obtained by direct measurement and it is thus possible to calculate what proportion of the whole power is converted into heat in the hearth.

The designers of the Greaves-Etchells furnace have a mathematical proof of the electrical balance of their system. In this proof a definite ratio is assumed between the voltage of the hearth-transformers and of the electrode-transformers. This ratio depends on, but is not equal to, the ratio between the impedance of the hearth-circuit and the impedance of the electrode-circuits. Taking a suitable value for the voltage ratio, it is shown that a balanced load is produced on the high-tension supply leads. The proof involves certain assumptions which may not be exactly correct, but it is practically satisfactory.

Electrical steadiness in this furnace, as in other furnaces of the electrode-hearth type, results from the use of a conducting hearth, since if one electrode, *D* for example, Fig. 1, makes contact with the metallic charge, the electric current will pass around the circuit *D, F, H, C, O, B,* and the resistance *FH* will prevent a dead short-circuit. Also the current will always pass through two transformer windings in different phases and this limits the amount of overload. The combination of delta and star windings also insures that the effect of a short-circuit by one electrode shall be distributed to three wires ot supply.

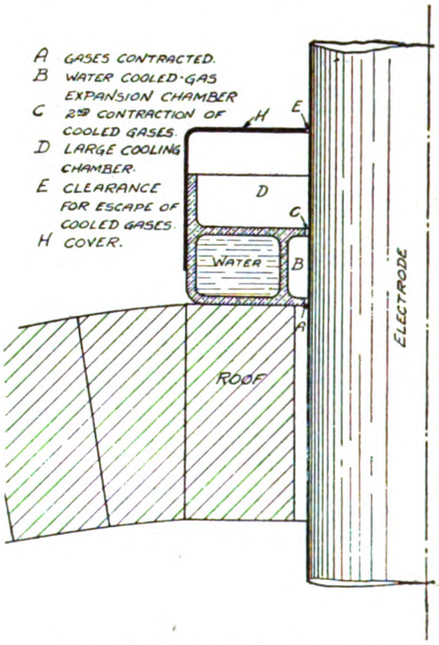
A GASES CONTRACTED.
B WATER COOLED-GAS EXPANSION CHAMBER
C 2ND CONTRACTION OF COOLED GASES.
D LARGE COOLING CHAMBER.
E CLEARANCE FOR ESCAPE OF COOLED GASES.
H COVER.
H
E
D
C
WATER
B
A
ROOF
ELECTRODE

Fig. 4—Electrode economizer.

Fig. 5 is a power record taken by an Esterline graphic wattmeter of a 6-ton Greaves-Etchells furnace melting and refining steel-scrap. The record was taken after a shutdown of 18 hours, and it will be seen that the power came up quickly to full load and was very steady during the heat, showing no sustained peaks. Even during the first 15 minutes the power was reasonably steady. The power was cut off during the slagging period and was lower towards the end of the heat when a lower voltage was employed. The steadiness of this record shows that the transformer capacity need not be much in excess of the normal load of the furnace.

The makers claim that the electrical arrangement of this furnace leads to the production of a substantial proportion of the heat in the furnace hearth and that in consequence: (1) More heat can be supplied to the furnace with a given size and number of electrodes. (2) As proportionately less heat is supplied to the arcs, the walls and roof of the furnace should last longer. (3) The bottom-heating will lead to circulation of the metal and this will facilitate the absorption of heat from the arcs and the refining of the steel by contact with the slag. (4) The bottom-heating will prevent any chilling of the steel on the hearth and thus will allow of a smaller consumption of electrical energy. The construction of large electric furnaces is limited by the amount of power that can be supplied through each electrode, and furnaces of this type, using four electrodes and with bottom-heating, should therefore be capable of a larger output than furnaces of the usual three-electrode construction. Moreover, as each electrode can operate by itself, and is independently contolled, there will be more flexibility in operating large furnaces, and the number of electrodes can be increased to any reasonable extent.

Fig. 6 shows in diagrammatic plan and elevation a Greaves-Etchells furnace of 60 to 90-ton capacity that is being built for the Ford Motor Company. It has eight 12-in. graphite electrodes and 12,000-kva. transformer capacity. The inside dimensions of the shell are about 16 ft. by 25 ft. and the funace is 7 ft. high inside the lining. This furnace has the capacity of a standard open hearth furnace, so that as a steel maker the electric furnace will no longer have the handicap of a smaller capacity when compared with the open hearth. The electrodes are arranged in two rows of four. Each pair of electrodes and the contact plate in the hearth, which is common to all, forms an electrical unit and is supplied by a 3,000-kva., 3-phase transformer with the connections shown in Fig. 1. It is possible, however, by means of an oil-switch, to supply all the power to the top electrodes. The electrode motors and winches are mounted on a framework above the furnace and each electrode-holder is lifted by two chains which pass over the sheaves shown in the figure and then directly to the winding drum. The bus-bars from each transformer pass interlaced, up the side of the furnace to a point from which flexible copper strips lead to the electrode-holders. Each holder is provided with insulated guides passing through the superstructure, so that it cannot be pulled to one side by the flexible connections. The furnace has five doors and a pouring spout and tilts endwise to pour.

Greaves-Etchells furnaces have been used largely by Sheffield steel companies, over 20 of these furnaces, ranging from 500 lbs. to 20 tons, having been installed in Sheffield and district for the production of the best grades of tool-steel and alloy-steel. In the United States two furnaces have been supplied to the Halcomb Steel Company, Syracuse, and five furnaces to the United States Navy Yard, while the British, Spanish, Chilean, Japanese, Argentine, Brazilian and New South Wales governments have all installed these furnaces for steel making.

Greaves-Etchells furnaces installed by the Ford Motor Company and by the Holmes Foundry Company at Port Huron, Mich., have been used for melting cast-iron borings and refining cupola iron for casting motor cylinders, piston rings, etc.

The furnaces at the Parkgate Works of Vickers, Ltd., in Sheffield have been used to make alloy-steel by the Duplex process; hot metal from the blast furnace being blown in a Bessemer converter and finished in the electric furnace.

Over 60 furnaces of the Greaves-Etchells type have been installed or contracted for since it was first introduced in 1915, and the makers consider that it is now the second in the world in respect to the tonnage of steel produced in any type of electric furnace. The *Iron Age*, January, 1922, lists 28 of these furnaces in the United States; one 50-ton, two 10-ton, five 6-ton, eight 3-ton, six 1-ton, five ½-ton and one 1/6-ton furnace.

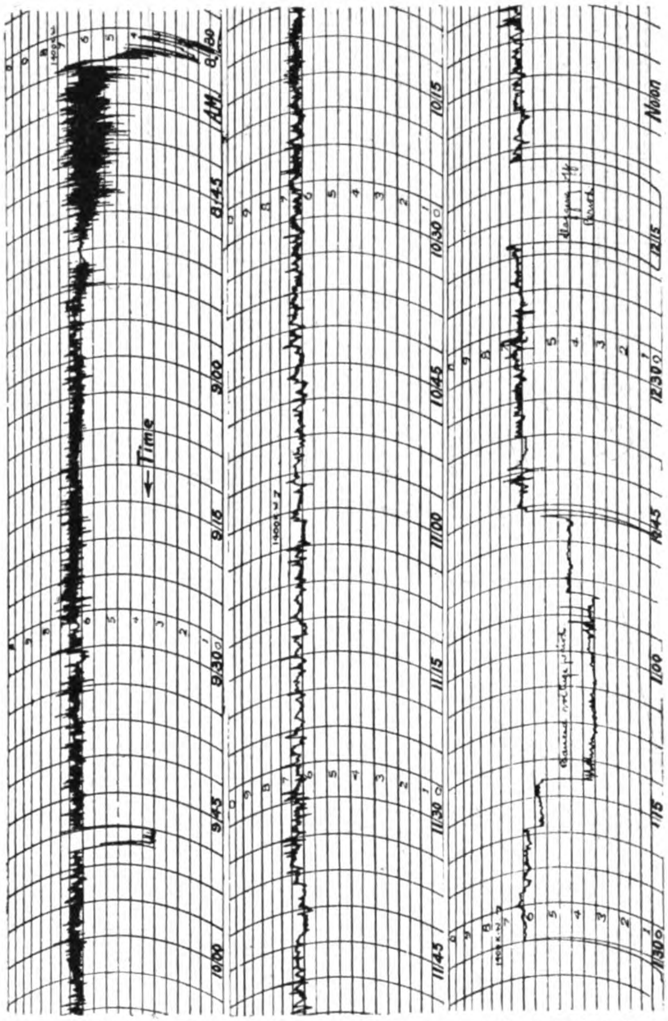

Fig. 5—Power chart of electric furnace melting and refining scrap.

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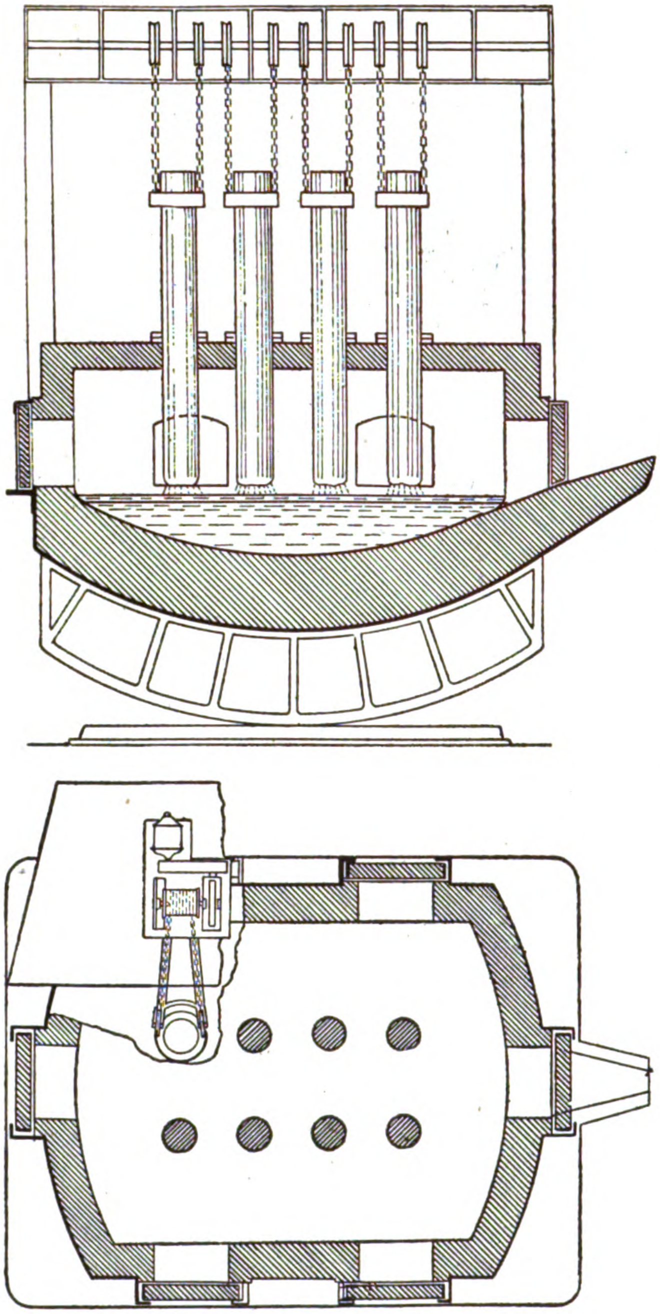

Fig. 6—Eight-electrode furnace.

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INDIANS PLANNING IRON EXPANSION

The largest iron and steel interests in India, the Tata Iron and Steel Works, are planning, according to reports received by the Department of Commerce, to enlarge their capacity by the end of 1923 to an output of 50,000 tons of pig iron and 425,000 tons of finished steel annually, a large increase over their present capacity of approximately 300,000 tons of pig iron and 125,000 tons of finished steel. This firm claims that it is the only producer of finished steel sections for the market in India at present.

The government has a small steel plant at Ichapore for the production of steel for ammunition and for government purposes but it is believed that none of this product is for sale in the market. The Bengal Iron Company, Ltd., is said to be producing more than 150,000 tons of pig iron annually. It is expected that an annual output of 180,000 tons of pig iron will be reached by the Indian Iron and Steel Company when its new works, being erected at Hirapur, Bengal, are completed. The proposition of erecting a modern steel plant with an output covering all basic steel products is being worked out, and a corporation for that purpose, the United Steel Corporation of Asia, Ltd., is in process of flotation. Several small companies have iron works under construction.

The Mysere Government is putting up the money for the erection at Phadravati, Shimega district, Mysere, of iron works to have a capacity of 20,000 tons.

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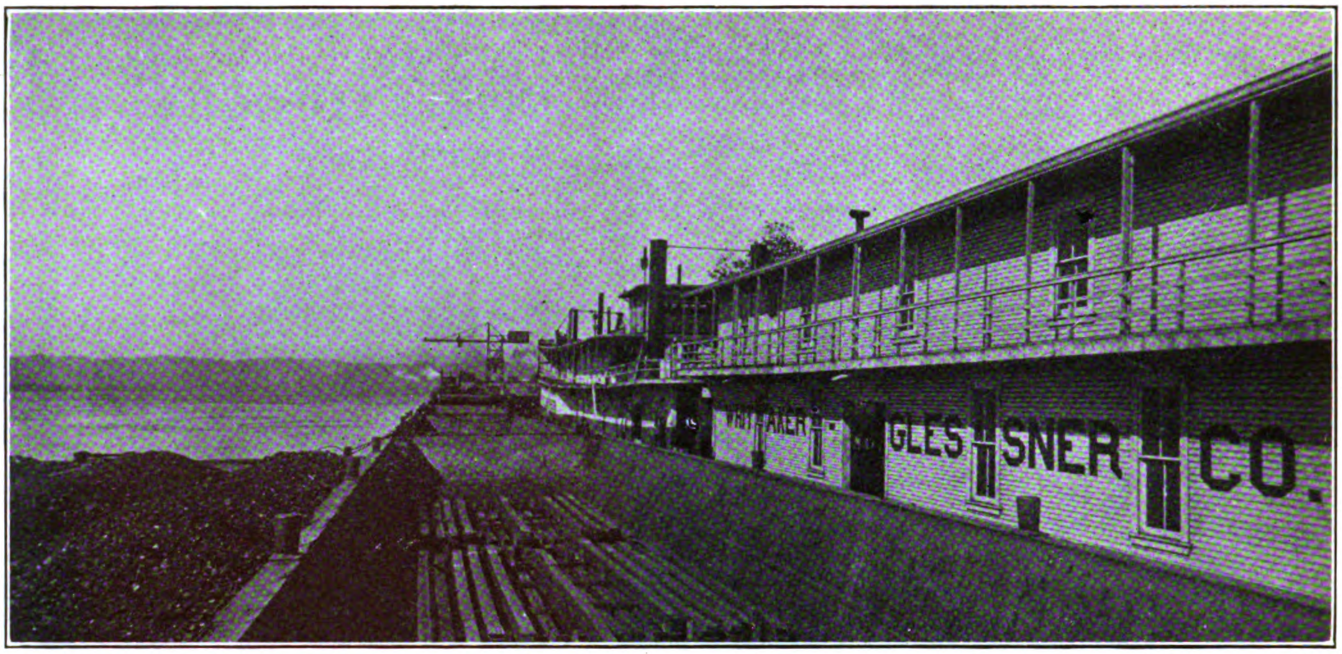

Fig. 1—River transportation facilities showing fleet of barges at company wharves on Ohio River at Portsmouth.

River Transportation Featured in Ohio Steel Plant

Complete Description of Steel Plant Where Raw Materials Are Converted into Steel Barrels, Wire, Nails and a Great Variety of Special Products.

By F. J. CROLIUS

MANY miles separate the famous Pittsburgh district, with its enormous concentration of iron and steel production units, from the lower Ohio River section, where are being developed newer and more modern steel plants. Great as is the distance, even greater is the difference in plant characteristics and atmosphere.

The near Pittsburgh producing units have long since out-grown their general development limitations, and it is almost an axiom that the farther we remove from Pittsburgh, both upward on the Allegheny and Monongahela a swell as southward on the Ohio, the greater will be found the freedom for balanced development and the cleaner will be found the general atmosphere.

The limited confines due to the remarkably difficult topography of the immediate Pittsburgh territory have imposed excessive burdens upon plant engineers, hardly warranted by the original advantages, now largely out-worn or dissapated.

Added to the topographical limitations found in the immediate Pittsburgh district, and in a way closely related thereto, are the railroad transportation handicaps imposed by inadequate car supplies, car repairs and transfer yard facilities.

Several days frequently elapse before car loads find their way into or through the intracacies of the local Pittsburgh labyrinth.

These limitations do not occur at Portsmouth, Ohio, where the Whitaker-Glessner subsidiary of the Wheeling Steel Corporation has developed and will further develop a nearly ideal steel producing unit.

Situated near the junction of the Scioto River with the broad Ohio, the plant location occupies a natural plain entirely adequate, both as to length and width, for any logical development of an economic unit.

The river at this point is of sufficient depth and width to serve its dual purpose of transportation, both of raw materials and finished products, of fuels, and of unlimited water supply, the life blood of a large steel plant. Across the river rise the palisades and foot hills of Kentucky. Here we find the unusual combination of intense industrial activity and comfortable, enjoyable home life, spent not under an atmosphere of smoke and dirt and grim, but in clean breathable air and sunshine.

Labor responds with a remarkable optimism and the voice of immigration is less imperative.

Fig. 18 shows a street nearby the main gate.

RIVER TRANSPORTATION

Full advantage has been taken by the plant engineers of the exceptional advantages offered by the Ohio river.

Fine dock facilities for shipping finished product have been built, and as the view shown in Fig. 1 suggests, a constant commerce is maintained through the fleet of company steamers and barges.

Coal Handling Facilities.

An outstanding feature of this river bank development is shown in Fig. 2, a completely modern coal unloading dock, hoist and distributor. Back of the coal dock will be found a coal storage area for some 50,000 tons of coal, 30 days' supply, while at this point a complete concrete submerging basin for 300,000 tons of coal is projected and will ultimately be constructed.

The coal handling equipment was designed, built and installed by Heyl & Patterson, and combines an unusual flexibility of operations. From barges, about 100 feet below, it hoists in a 7½-ton bucket, dumps internally to conveyor hoist belt nearly 150 feet long on a high angle of elevation, or revolves to dump to stock, or to broad guage cars. Or it hoists from stock to cars or belt—a range of operation covering every emergency.

The capacity of this equipment is 600 tons in 10 hours, and its operation is by two 175 hp. motors in parallel on one magnetic control board, one 90 hp. motor on the rack, one 30 hp. on revolve, two 30 hp. motors on the bridge travel. A 20-ton transfer car completes the operation.

The coal supply is developed from company mine operations both from modern mines along the Kanawha River, or from the recently opened La Belle mines, another subsidiary, on the lower Allegheny. A large fleet of barges and steamers serve the purpose of storage and transit.

From the unloading of the coal to the shipping of the finished product, whether it be billets, or sheet bars, or wire or nails, or steel barrels, or galvanized range boilers, the "process flow" through the various departments and stages of production continues in nearly an unbroken sequence. Internal transportation is maintained and simplified by the adoption of standard-broad-gauge tracks and equipment throughout. Endless confusion, duplication of motive power, dangerous crossings are thus avoided. Twenty locomotives are adequate to serve maximum production requirements.

A glance at Fig. 3, which details the general plan of the entire group of mills, will afford a comprehensive idea of this ideal grouping.

At the extreme eastern section are located the by-product coke-ovens, which furnish a constant source of uniform quality coke for the blast furnace, and coke-oven gas for mill purposes. These 108 ovens are of the Semet-Solvay type, and the by-product operations are under the direct supervision of the Semet-Solvey organization.

Blast Furnace.

A strictly new and modern blast furnace now about four years old (shown in Fig. 4) of 500 tons daily

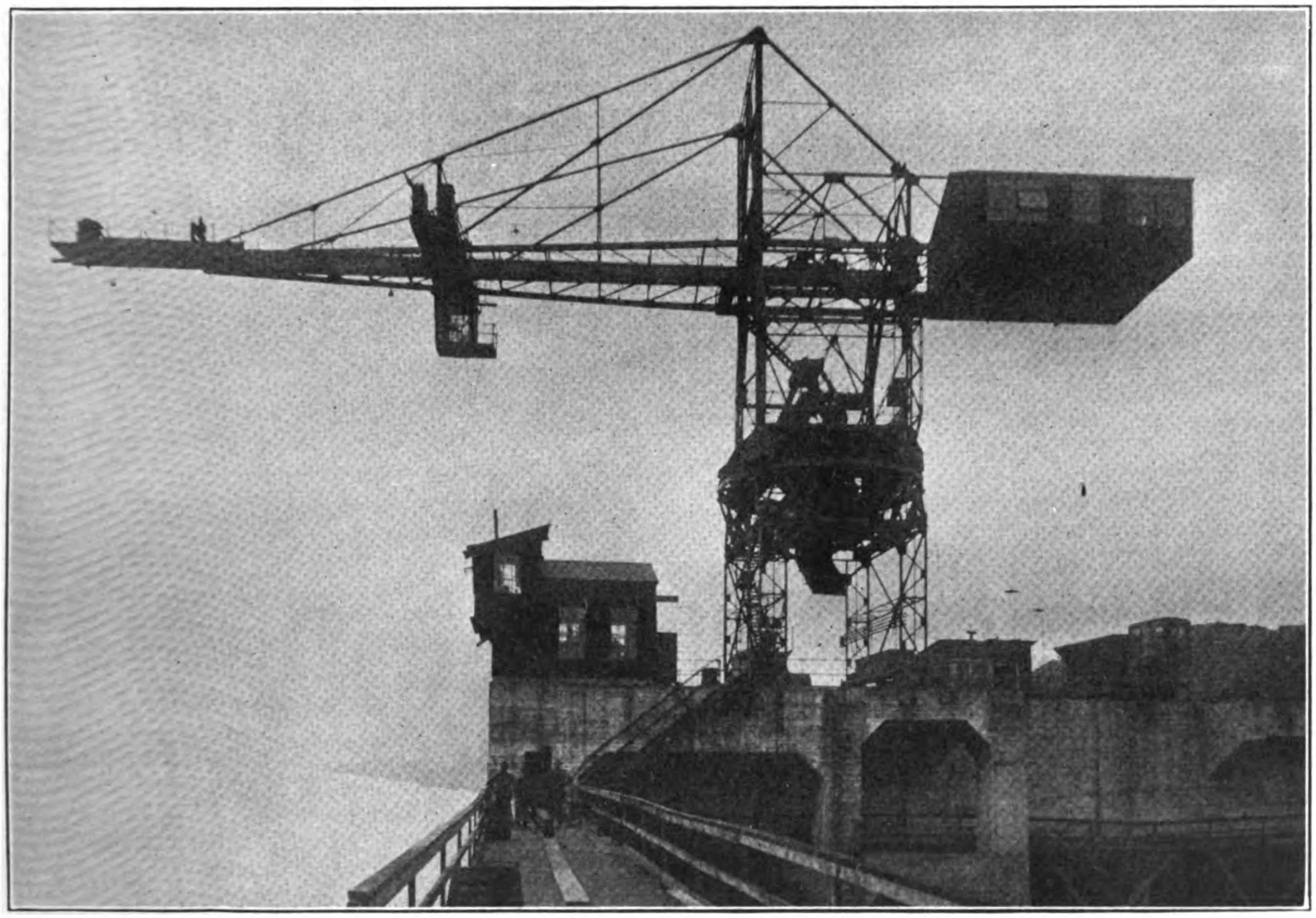

Fig. 2—Modern coal unloading dock and transfer. This modern equipment develops a degree of flexibility seldom found at coal docks. Barges can be unloaded direct to belt conveyor to railroad cars, or to stock, or vice versa.

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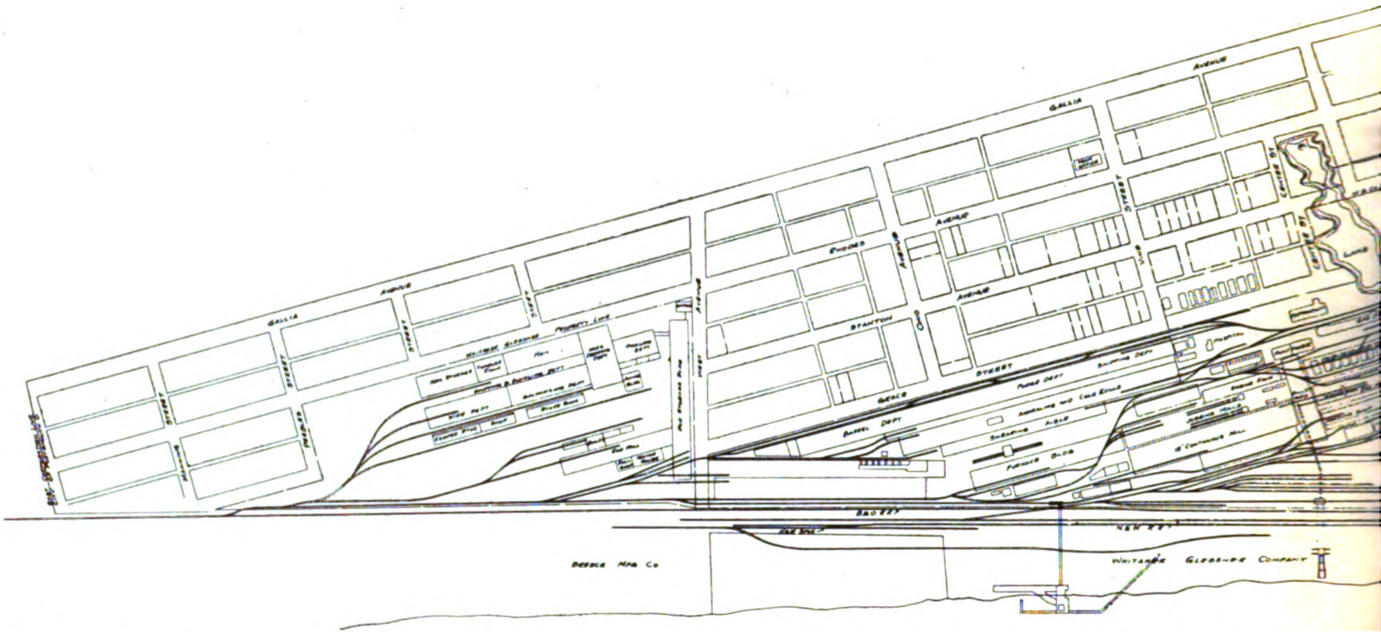


Fig. 3.—General plan of Portsmouth Steel Works. The extent of developed river frontage, the accessibility of railroad faciliti

capacity, working on soft Mesaba ores has no difficulty in maintaining a monthly average production of approximately 18,000 tons of steel making iron. Most of this metal is charged hot direct to the open-hearth, with but a small balance pigged for stocking purposes. Lake ores reach Portsmouth from either the ports of Toledo or Cleveland, entering the plant over the Chesapeake and Ohio, or the Norfolk and Western, both of which roads are available, and have excellent interconnections with the New York Central and Pennsylvania Railroad systems on the north, as well as the Baltimore and Ohio on the east.

Ores are unloaded, stocked and distributed by means of a mammoth ore-bridge, shown in Fig. 5.

This ore-bridge, designed and built by Heyl & Patterson, has an over-all span of 250 ft., with over hanging ends of 50 ft. each. Ten-ton ore buckets are in service.

Electrically operated ore-bins serve adequate stock house needs, and charges are handled, conveyed and hoisted by motors.

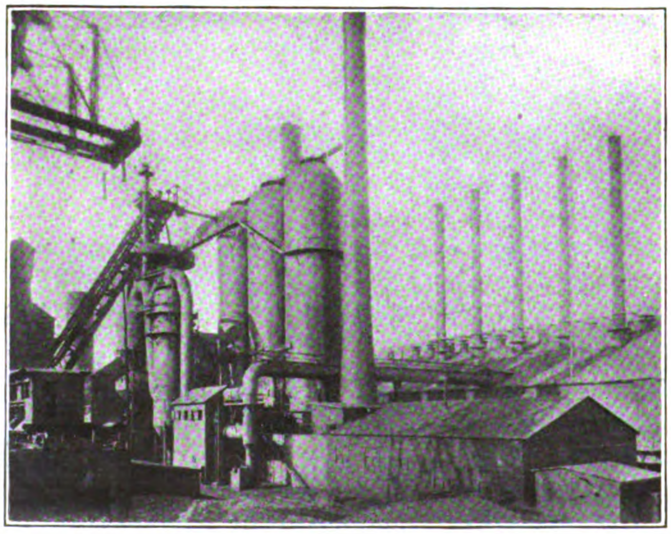


Fig. 4—View of blast furnace. Showing overhang of ore bridge in left upper foreground, stoves in center and power house at right background.

No gas-washers are employed, as no gas engine drives, either for power or blowing are included in the heat-balance scheme. Two turbo-blowers furnish wind to the furnace.

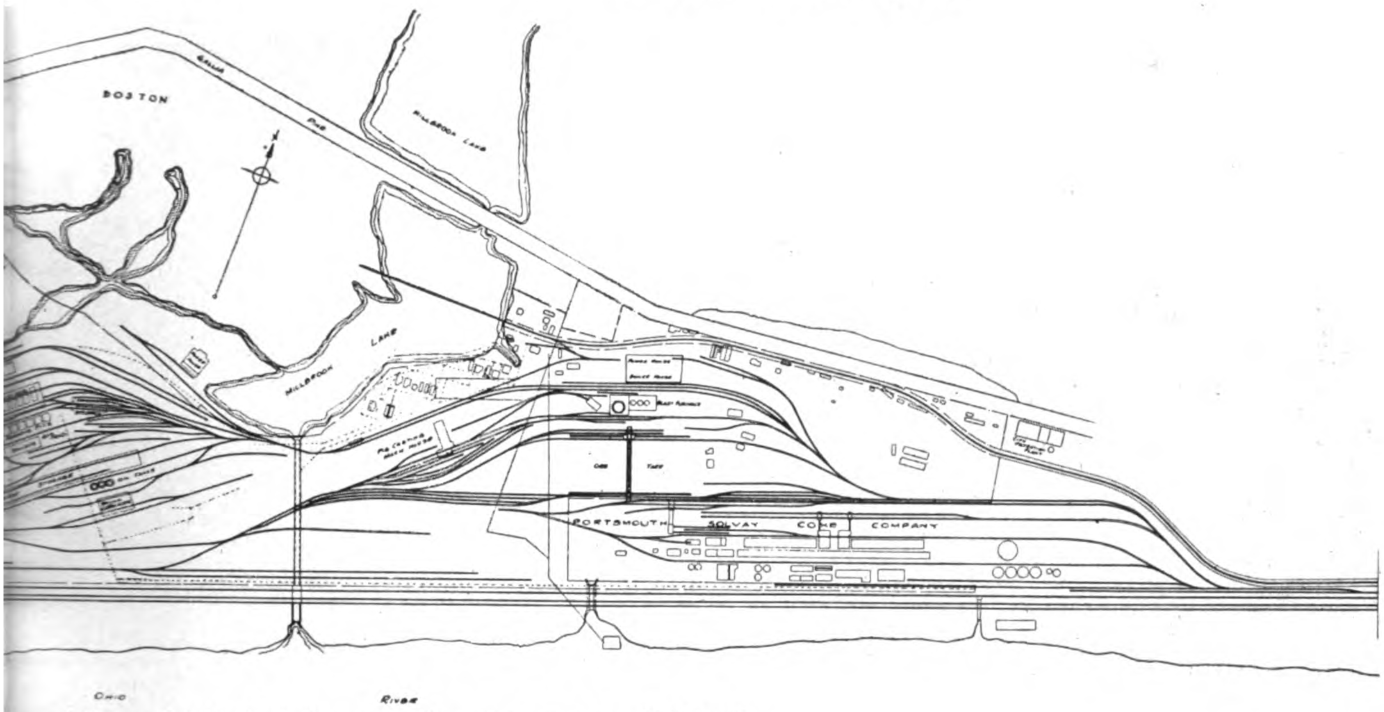
Unwashed blast furnace gas, burned under boilers develop steam for the turbo-blowers and for the 10,000 kw. and two 3,000 kw. turbo-generators. The excess power for other than furnace requirements compares very favorably with any single furnace operation.

Power House.

Eight 500 hp. Stirling boilers operating at 190 lb., 125 deg. superheat constitute the steam generating unit at this blast furnace power house. Provision has been made for emergency coal firing, due to gas shortages incident upon tapping periods or uneven working furnace, by installing automatic stokers in combination with blast furnace gas, in specially designed furnaces. Riley underfeed stokers were selected for this difficult service, and the high setting of the Stirling boilers made possible adequate combustion chambers.

Steam charts observed indicate very satisfactory results, with a minimum of coal and labor. No coke dust is burned, as the amount available is negligible.

Fig. 7 shows an interior view of one of the boiler houses which is nearly typical of all four steam generating units which develop the total plant steam needs, close inspection will evidence the use of the most modern gas analyzing, steam, air and water flow metering and recording devices that recent science has developed. Fig. 8 shows a typical multiple CO_2 Recorder of the highest type. Very careful supervision is maintained, and this as well as all other boiler houses are immaculate, even to the point of appearing ornate with their well conceived arrangement of paint-colorings for all the various piping. If a man can tell the difference between bright-red and dark-gray, there need never be any difficulty in finding his right valves in emergencies.



h main line and interplant, the production sequence are well defined.

The entire blast furnace production is taken care of by ten 65-ton open hearth furnaces. No mixer is employed and hot-metal ladles serve as direct transportation.

Open Hearth.

The general construction of the open hearth follows closely the usual layout for furnaces of this type, size and character of product, both on the charging floor side and the cinder pit side. Eight of the furnaces are of the usual natural draft porting, while two are of the modified pressure port design, with water cooled ports.

Fig. 9 gives a fairly adequate idea of the open hearth furnaces from the tapping side. The picture shows but one of the two 125-ton Alliance four-girder ladle cranes. These two cranes over the furnaces are supplemented by one 10-ton crane, all three cranes being carried on the same run-way, and there is one 100-ton Alliance crane in the ladle house.

Charges are handled by one 7½-ton Morgan H. T. charging machine, one 5-ton and one 3-ton Wellman-Seaver-Morgan charging machines.

The stock yard is served by two 5-ton Alliance and one 7-ton Alliance cranes, equipped with 56-in. stock magnets, while the two stripper buildings each house one 150-ton Morgan screw type stripper, equipped with auxiliary hoists for mould handling.

The average production of these 10 furnaces totals well over 38,000 tons of steel.

An interestnig feature of the metal handling methods are the four mold ingot buggies, designed by Mr. Stoop, formerly general superintendent. These trans-

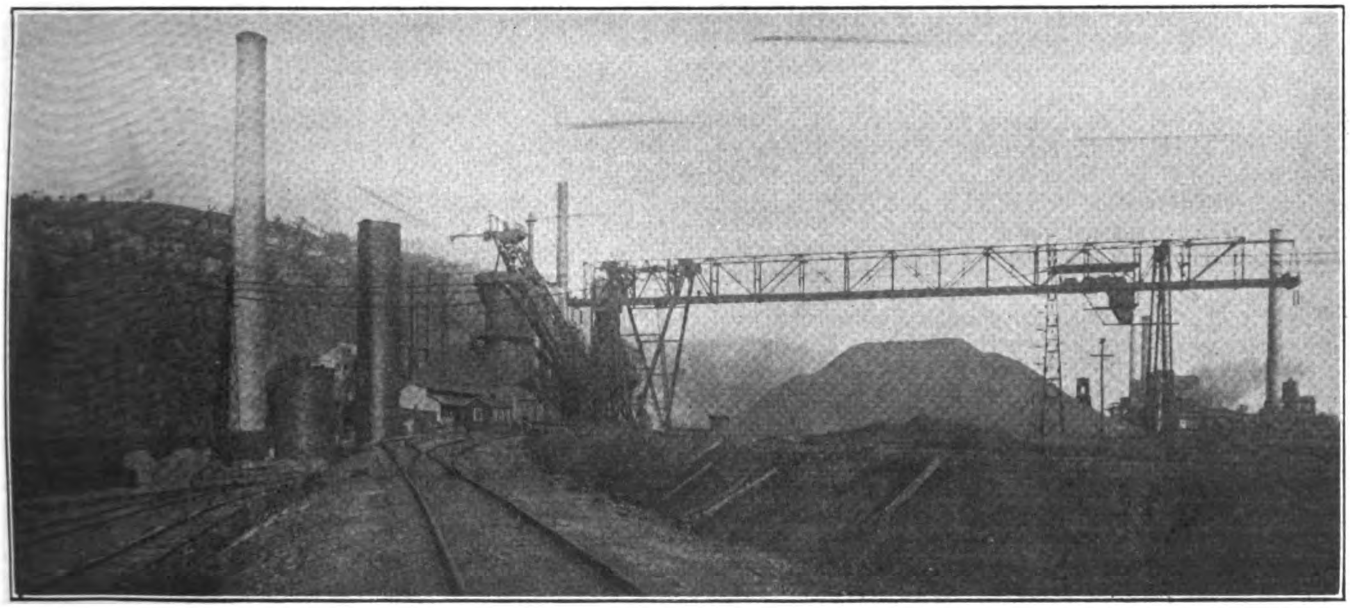


Fig. 5—Two hundred and fifty foot ore bridge with raw material piles. The water tank purification plant appears in the left foreground with the blast furnace at left of ore bridge.

port four 8,300 lb. ingots to the stripper and thence to the blooming mill.

This concentration of ingot capacity greatly econmizes trackage space and numerically reduces the necessary ingot buggies.

Each open hearth furnace finds its fuel supply from two Morgan gas producers — 20 producers in all, arranged in separate producer house, parallel and adjoining the main open hearth building. Coal for charging these 20 producers is handled by one 5-ton conveyor crane.

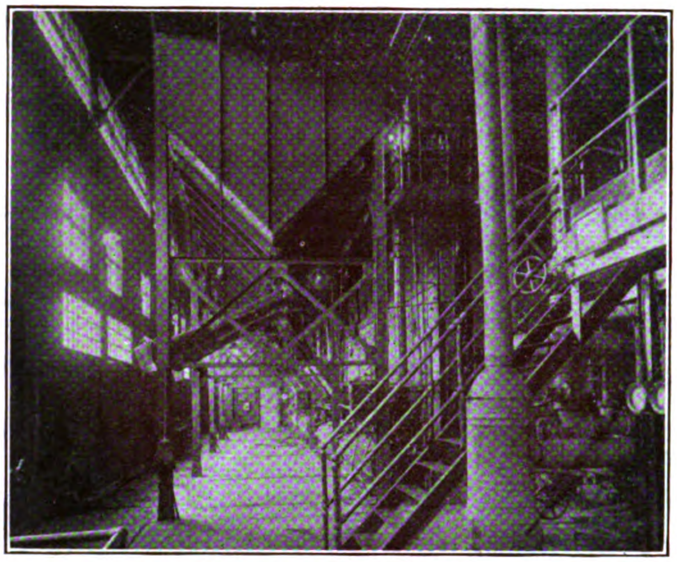


Fig. 7—Interior of typical boiler house at Portsmouth. Vertical tube boilers allow low-hung overhead coal bunkers, with chutes direct to stoker hoppers. View shows a number of chutes withdrawn for natural gas burning.

The skull-cracker building in connection with the open hearth presents the interesting feature of a two-level drop.

On a run-way level of 60 feet, one craneway carries one 25-ton Morgan crane with one 10-ton auxiliary, while for exceptionally heavy breaking, an upper level of 90 feet carries a craneway upon which a 10-ton Morgan crane with magnet operates.

Steam Driven Mills.

The entire capacity of the open hearth is broken down by the 35-in. blooming mill. This mill, one of the few steam driven units, is large enough and fast enough to average well over 35,000 tons of ingots rolled to various bloom sizes per month.

A Mackintosh Hemphill 42-in. x 60-in. duplex, geared, blooming mill engine operating on 175 lb. 100 deg. superheat steam with 26½ in. vacuum furnishes the mill drive. Three other steam driven mills supplement the general production scheme.

A 24-in. bar mill, operated by a Mesta-Corliss, 36-in. x 60-in. engine at 70 rpm.

A 2-high jobbing mill and a 3-high jobbing mill producing sheets and light plates. The engines driving these three mills exhaust through a regenerator into two 500 kw. General Electric mixed pressure turbines.

These latter steam-driven mills comprise the early equipment around which the greater more modern development expanded, and at no distant future will give way to the general scheme of motor-driven operation.

Adequate crane facilities keep fluid the course of materials to and away from these mills.

Over the blooming mill soaking pits are two 7½-ton Morgan S. P. cranes.

Over the rolls are one 30-ton Morgan and one 15-ton Morgan crane, while over the slab yard is one 25-ton Morgan with 10-ton auxiliary, ande 10-ton Morgan crane with 5-ton auxiliary. The jobbing mills have one 15-ton and one 10-ton Morgan crane over the furnaces, besides a revolving charging machine on the furnace floor.

Motor Driven Mills.

The major operation of the total production scheme, revolves itself around the recently installed 18-in. continuous Morgan sheet bar mill. This most modern mill is driven by a 5,000 hp. General Electric 2,200-volt induction motor, operating at 450 rpm,. no load speed on main rolls, through complete magnetic control.

The 18-In. Sheet-Bar Mill.

Fig. 10 gives an excellent idea of the completeness and scope of this milling operation, with the motor and controls housed in sperate brick building at the extreme right of the picture.

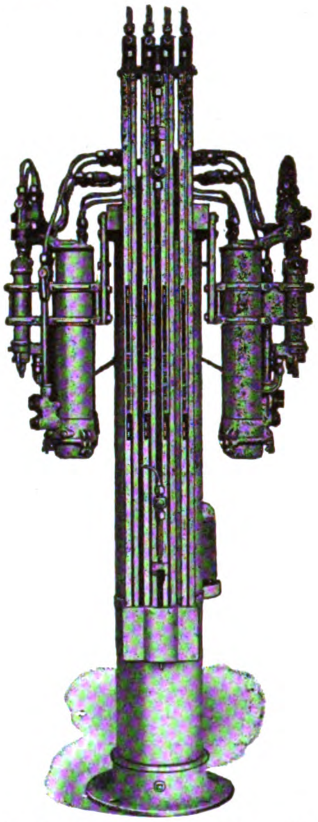


Fig. 8—Four unit Uehling CO_2 recorder. The special features of this instrument are continuous record, dry absorption, absence of moving parts, and separate simultaneous indicator.

Fig. 10 shows the mill assembled for rolling sheet bars.

The mill was built by the Morgan Construction Company of Worcester, Mass., and consist of six stands of 18-in. roughing and finishing rolls, together with two edging mills, located respectively in front of the first and third roughing passes.

Provision is made for drawing loops between each pass, when rolling sheet bar, and by use of the edging rolls, sheet bar with good edges and accurate weights

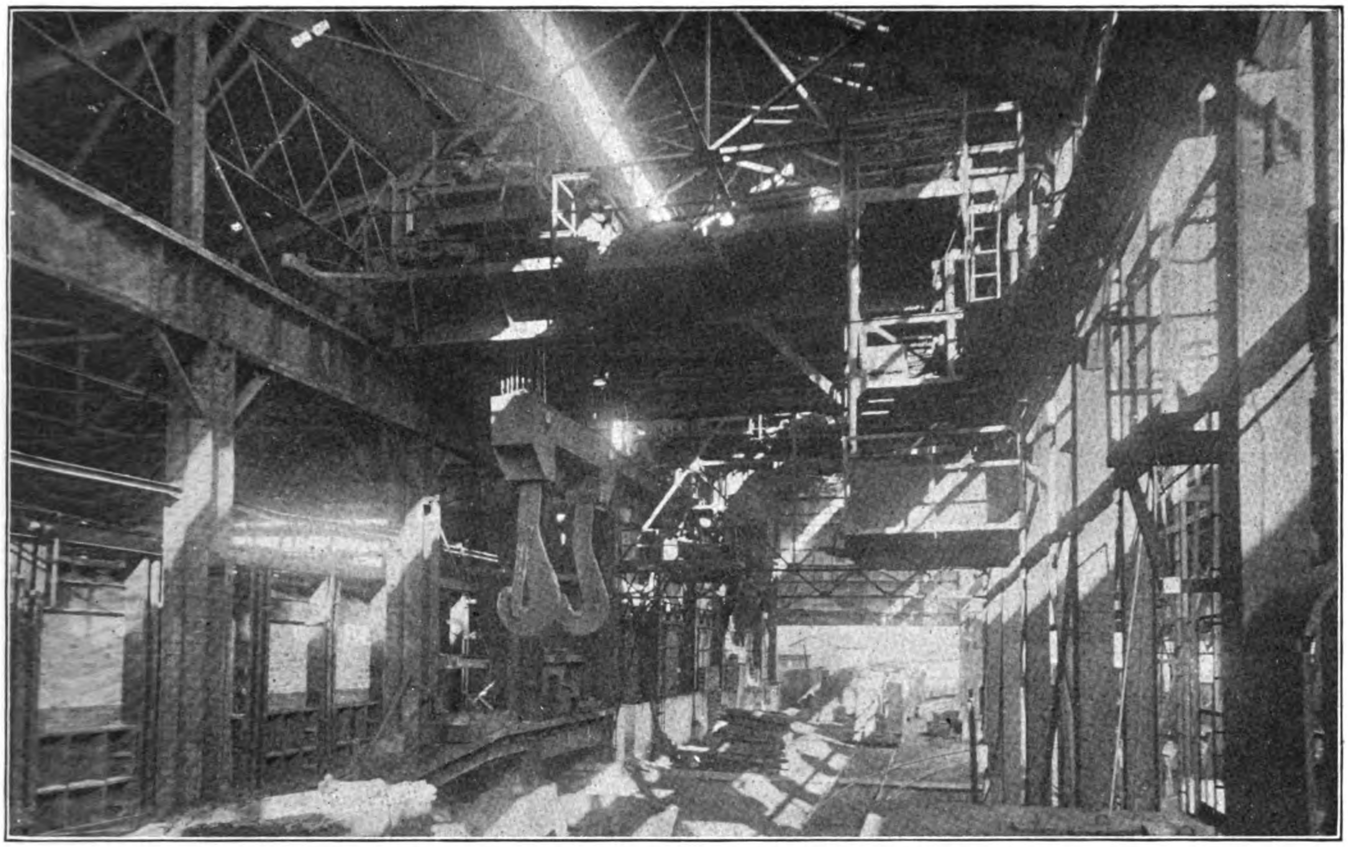


Fig. 9—View of open hearth, taken from the tapping side, showing cinder pits, ladle crane, etc. One furnace is under repair as shown by the open doors at left foreground.

from slabs 12-in. wide by 2½-in. thick to 10-lb. bar, without recourse to the tongue and groove passes customarily used.

A roll change is interesting with this operation. Across the craneway will be noticed a complete set of housings, a duplicate mill in fact.

The shoes are so arranged that each mill can be lifted off separately and replaced with mills assembled, ready for rolling blooms from 4-in. square to billets 1½-in. square, twisting guides being placed between each alternate pass of rolls.

The skew approach table built by the Wheeling Mold & Foundry Company is provided with rollers, 15 in. in diameter, set on angle with the center line of the table. This allows the mill operator to quickly center the blooms on the table ready for the first pass as V grooves 3-in. deep with 45 degree sloping sides are cut in each roller. When the bloom is delivered to the table, it clings to the side guard while traveling, but just before being cropped by the preliminary sheer, the table is reversed and the bloom travels laterally across to the center where it drops into the V groove and is ready for the first pass. All of the table gears are cut gears and run in oil. Hyatt bearings being used throughout.

Fig. 11 shows the end of the shear table elevated to deliver sheet bar to the pinch rolls, which in turn deliver the bars to removable piles shown in Fig. 12. Here the sheet bars are stacked approximately 24 in. high and then removed by a lifting beam with multiple hooks attached to the overhead crane, which conveys to the cooling bed.

When rolling billets, the end of the shear approach table is lowered level with the skew assembling table from which the bar piles have been removed. This table has a capacity of 8,000 lbs. of 1½-in. billets and is provided with skewed rollers which group the billets of approximately 30 ft. lengths and delivers them by means of a strait edge to the cooling beds.

The cooling beds were designed and built by the Morgan Construction Company. They are 44 ft. x 80 ft. with C. I. wearing plates. Billets are pushed across this bed at a speed of 188 ft. per minute, by the action of tilting g-devils placed 6 ft. apart, to a piling bin located in the adjoining building where the billets are weighed and transferred to storage.

The mill building itself is 103 ft. wide by 717 ft. long. In the lower end are conveniently located the sheet bar shears and the picklers.

The main mill drive was built by the Woodward Machine Company of Wooster, Ohio, and consists of a double helical pinion and gear unit which reduces the speed from 440 to 80 rpm. The forged steel pinion is cut integral with the shaft while the gear is of cast steel with split hubs held by shrink rings.

The gear cover is of cast iron tightened down to permit enclosed in oil operation.

The bearings and pinions are lubricated by a Bowser gravity feed oiling system.

An Edward-Carroll adjustable flying shear, steam operated, allows the cutting of any desired length of sheet bar.

The capacity of this mill runs into the huge total of 40,000 tons of 10-lb. sheet bar per month.

Two 25-ton Morgan cranes with 10-ton auxiliary maintain this operation.

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Sheet Mills.

Sheets for various purposes, plain, galvanized, corrugated, barrels, tanks and fine automobile requirements are rolled on an 8-stand sheet mill, motor driven by a 1,600-hp., 2200-volt induction motor operating at approximately 270 rpm.

Shown in Fig. 13 are four 4-stand cold rolled sheet finishing mills, each stand driven by 300-hp., 2200-volt induction motors. Fine crane equipment supplies these mill units.

One 40-ton Alliance with 10-ton auxiliary, one 20-ton Alliance with 10-ton auxiliary, with one 20-ton Alliance over the sheet and pair furnaces and one 50-ton Alliance with 10-ton auxiliary and two 10-ton Alliance with 5-ton auxiliary over the annealing furnaces, two 5-ton mono-rail coal distributing lorries convey and charge the coal requirements of the annealing furnaces, which are stoker fired.

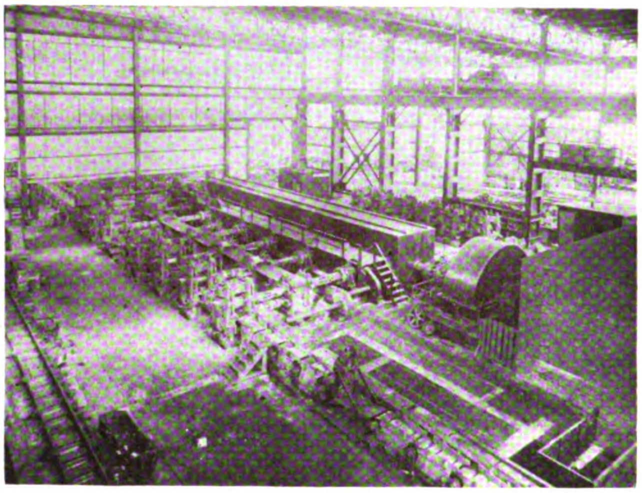


Fig. 10 — View 18-inch Morgan continuous sheet bar mill. The motor room is at the extreme right, with the enclosed gears and pinions and drive shaft in center.

Fig. 14 suggests in perspective the size and space required for the annealing operation. It shows the annealing boxes withdrawn from the furnaces in the left background, ranged upon the floor during the carburizing process.

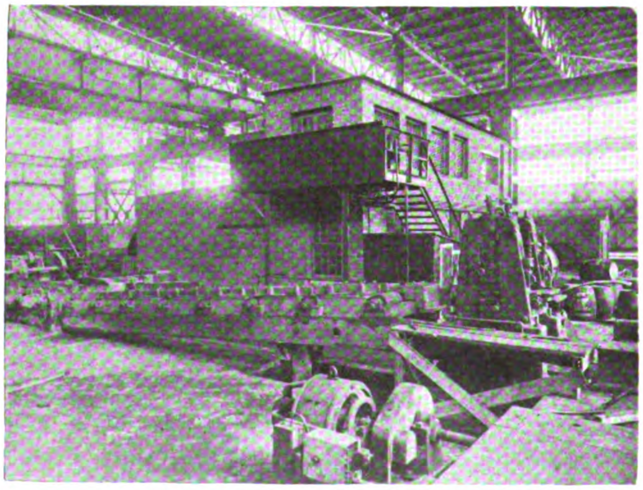


Fig. 11—Shear table, elevated to deliver sheet bar to the pinch rolls. This table has a capacity of 8,000 lbs. of 1½-billets per hour.

Roughing Mills.

The roughing mill operation is also motor driven but by a variable speed motor of 2800 hp. designed and built by the General Electric Company. The speed of this mill is 200 rpm. while the auxiliary motors, three 800 hp variable speed General Electric, operate from 70 to 350 rpm.

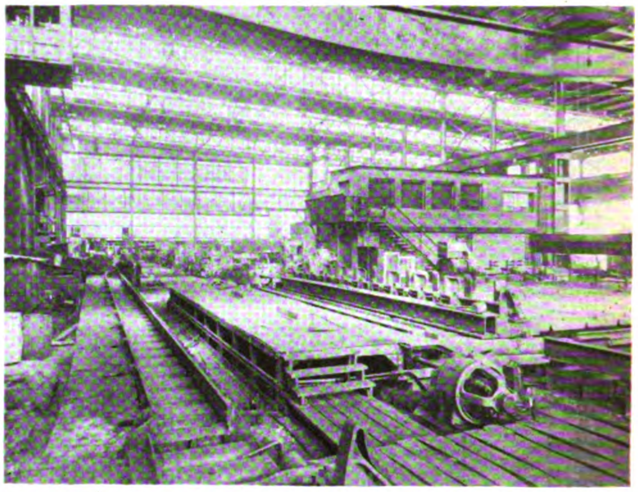


Fig. 12—Piling Table. Here the sheet bars are piled to a height of approximately 24 inches ready for lifting and removal to the cooling beds.

This group of completely motorized sheet mills is a recent addition; modern in every respect, installed in spacious, finely lighted, well ventilated buildings and with excellent internal transportation facilities.

The sheet mill crane runway carries one 40-ton Alliance and two 20-ton Alliance cranes, each with 10-ton auxiliaries, while the 8-sheet and pair furnaces are served by one 20-ton Alliance crane.

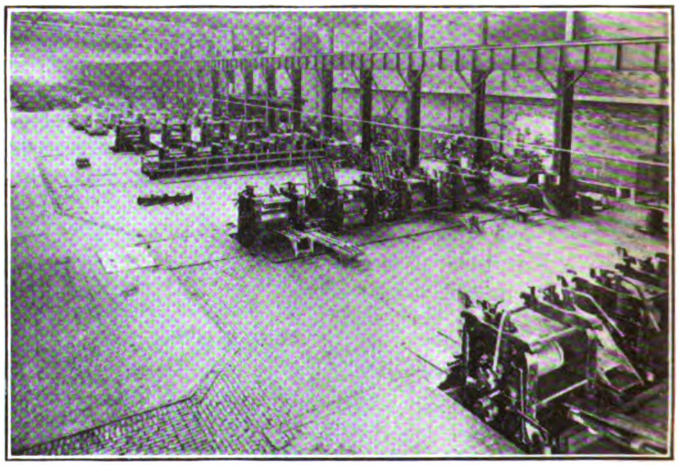


Fig. 13—Perspective of cold roll stands. Plenty of room has been allowed for comfortable and rapid working conditions.

The roughing stands are driven by a 2800/1400 hp., 400/200 rpm., 600-volt, dc. motor and the intermediate and two finishing stands each are driven by a 800/355 hp., 706/320 rpm., 600-volt, dc. motor. Speed regulation on these motors will be obtained by means of field resistance on the motors and also by means of voltage regulation on the generators which supply these motors with power.

These mill motors will all be supplied with power from a 3000-kw., 2200-volt, ac. to 600-volt, dc., 600-rpm., synchronous motor driven motor generator set consisting of two 1500 kw., 40 degree temperature rise, 600-volt, dc. generators mounted on common bedplate and direct connected to one 4200-kva., 2200-volt, 3-phase, 60-cycle, .80 power factor synchronous motor.

The dc. mill motors and the dc. generators will all be excited by a 90-kw., 2200-volt, ac. to 250-volt, dc. motor driven exciter set.

All of the above equipment together with the necessary switchboards and control boards for the motors, two 750-kw., 2200-volt, ac. to 250-volt, dc. motor generator sets and three 400-kva., 2200-volt to 220-volt, single-phase transformers are installed in a brick substation building 125 ft. long by 45 ft. wide located adjacent to the mill building.

The two 750-kw. motor generator sets mentioned above will be used for driving the individual motor driven wire blocks in the wire drawing department, electric cranes and other dc. surface motors. Power will be transmitted between the sub-station building and these various points of consumption by means of eight circuits of one million CM wire installed in fibre conduit which will be run under ground and set in concrete.

The three 400 kva., single-phase transformers furnish power for the various ac. surface motors throughout the plant.

Annealing Furnaces.

The annealing furnaces are stoker fired, all coal being handled by two 5-ton lorries carried on mono-rail equipment.

The crane way over the annealing furnace floor carries one 50-ton Alliance crane with 10-ton auxiliary and two 10-ton Alliance cranes with 5-ton auxiliaries.

The capacity of this sheet mill group varies monthly divided roughly between black, galvanized and corrugated sheets.

Ample warehouse facilities for sheet storage have been provided, warehouse receivals and withdrawals being handled by one 10-ton Alliance single hoist crane.

Steel Barrel and Range Boiler Departments.

Two major specialties are subsidiary to and contingent upon the sheet mill production; steel barrels and range-boilers. They are both of special interest not only from the magnitude of the production schedule, but also for the excellent facilities employed for this highly specialized operation.

If a visitor were blindfolded, and led through these fabricating shops, and the bandages were unexpectedly removed at a point where the smell of fresh paint was strong enough to suggest that he were in a paint factory—not a steel mill—he would be greatly astonished to find himself surrounded by barrels; steel barrels, of the latest design, by the thousands, in all stages of manufacture, from the sheet to the welded, painted finished barrel. The making of a reliable steel barrel is an art, and at Portsmouth 2200 barrels per day are finished and painted by hand.

Careful experiments have demonstrated that hand painting is preferable, and more economical than dipping or spraying or any other known method.

Adjoining the barrel department is located the range boiler production. The mechanics of the two operations are not dissimilar, the shaping, welding, riveting, galvanizing and testing following the same general routine.

Nearly 800 of these galvanized range boilers of various sizes and plate thicknesses are finished daily. Every house holder is familiar with their appearance, but few have any idea of the process of their manufacture. Riveting and welding of the finest character and workmanship is an essential. The number of rivets used in this shop is so great and the quality and specification of the rivets so important, that a number of rivet machines have recently been installed to guarantee this unusual demand. Each one of these 800 boilers is subjected to a severe hydrostatic test before going to warehouse or storage.

Rod, Wire and Nail Mill.

As a further step in the plan and policy of carrying production to the finished product, and distributing that product direct through the company's own warehouse system, activities at Portsmouth have been expanded to include a new rod, wire and nail mill.

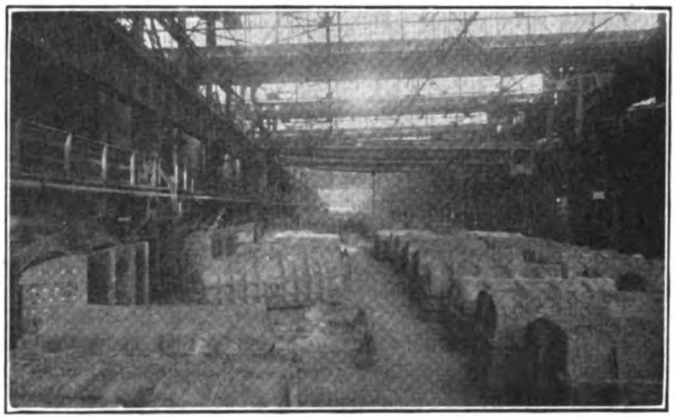


Fig. 14—View of annealing department, showing the great space required for withdrawal of annealing boxes and their disposition upon the floor during the carburizing period. Crane service is essential two of the three cranes appear in the background.

Reference to Fig. 1 shows the mill location across West avenue at the extreme left of the plan.

We are indebted to Mr. George A. Paff, superintendent of the department under whose personal direction the work has progressed, for the detailed description, which follows:

The rod and wire mills now under construction, are located on a triangular site of approximately 25 acres.

One corner of the triangle is connected with the other finishing mills of the steel works, so that the new plant is served by the same inter-mill system of tracks, which enables the present mill railroad crews and motive power to handle all the required switching.

The new buildings cover a total area of 365,000 sq. ft. and the arrangement of the various departments is sufficiently flexible to permit of future expansion that will be limited only by property line boundaries. The bulidings are practically all of the Aiken Roof type, which gives a maximum of natural light.

The finishing group of buildings are of brick and concrete construction.

A unique feature of the entire plant is the well worked out system of indestructible truckways, which were laid out with a view to the advantages of moving all material by means of storage battery tractors. The plant, as a whole, is also amply provided with overhead crane service, which, supplemented by the tractor service means that the laborious transferring of material by manual labor will be reduced to a minimum. The type of construction that has been followed throughout, both as to buildings and floors, will result in a maintenance cost that will be practically "nil."

Owing to the triangular shape of the property, it was not practical to have the progression of manufacture in a straight line, but this has been overcome by what might be termed a "Horseshoe" shaped lay-out which means that material, in going through the various manufacturing processes will actually travel after the fashion of a loop or horseshoe path of progression which after all, has numerous advantages over the straight line arrangement. In this manner, all departments are more nearly continguous to the various shops, storeroom, and other maintenance departments. The center of the horseshoe has been left entirely clear for further development.

Rod Mill.

The roll mill proper is housed in a building, 70 x 475 ft. which connects with an electric substation 45 x 200 ft. These buildings are directly connected and at right angles with a rod storage and shipping building, 80 x 682 ft.

The rod mill can be best described as being practically a return in principle to the original type of Morgan continuous mill, for the reason that the repeater system which has been used more or less in recent years in continuous rolling, is eliminated.

There are, however, a number of novel features that were not present in the old direct type of continuous rod mill. Seventeen passes are employed instead of the conventional sixteen (16) passes, thus enabling the mill to more easily produce from a 30 ft. by 1¾-in. square billet, a more uniform product, it being planned on this mill, to roll a No. 5½ gauge (.200) instead of a No. 5 gauge (.207) rod. The advantage of such a product will be quite obvious to those familiar with the manufacture of wire and wire products.

Another departure will be the division of the four (4) finishing passes into two (2) separate roll trains of four (4) stands each. This perhaps can be better described by saying that the mill is what is known as a two-strand mill, each set of rolls carrying two strands up to and including the thirteenth pass. After leaving the thirteenth pass the strands separate in the form of a "Y," after which the parallel (but more widely separated) course is resumed, each strand is individually finished in its own last four passes. This offers a very marked advantage in enabling the roller to treat and adjust each strand individually without interference with the companion strand. This will undoubtedly prove a most advanced step in continuous mill construction.

"The general arrangement of the continuous roll trains provides for a 12-in. roughing train of seven passes, followed by an interval of 20 ft., after which there occurs four (4) 10-in. additional roughing mill stands, then another space of 23 ft., followed by two (2) 10-in. preliminary finishing passes, when another gap of 28 ft. occurs before the introduction of the strands into the twin trains of the four (4) final finishing stands hereinbefore described."

Another very radical improvement which has not been heretofore employed, will be a coiling and conveying system which seems to represent the very latest development in that line. Each reel will be served by its own conveyor and as six (6) reels will be provided for coiling the rods, it follows that there will be six (6) individual conveyors for transferring the rods from the mill to the rod storage. These conveyors will travel intermittently, instead of continuously. When the reel is discharged, the conveyor will automatically move forward about four feet more or less, then come to a positive stop and remain at rest until another bundle is produced and the cycle repeated. All of the conveyors will be of the Muffle type which, coupled with the intermittent progressive feature, offers what would seem to be the very last word in producing a rod quite free from the evils of oxidation, and at the same time guaranteeing a uniform softness, free from hard and brittle spots.

Rod Storage:

As intimated above, the rod storage building covers an area in excess of 54,000 sq. ft. In this building there is installed a rook carrier which picks up the bundles from the conveyors heretofore described. This carrier will serve to convey the rods the full length of the rod storage building, which will permit of a most convenient method of distribution for storage, shipment, or for further working in the wire department and finishing mills.

While in transit on this carrier, the rods will be gauged, culled, and bundled.

The rod storage is served by an overhead electric crane, which covers the entire area.

Pickling Department.

The pickling department is served by two (2) 16-ft. radius steam jib cranes, the pickling being performed in double rectangular tanks of a late design. Ample provision has been made for the storage of acid and lime.

An improved fourteen (14) track Baker is being installed, each track to hold eight (8) buggies of rods, giving the baker a total capacity of 112 buggies.

Wire Drawing Department.

Connected with the pickling department is the wire drawing room, 128 x 250 ft., which provides ample space for, sooner or later, drawing the entire tonnage of rods that will be produced by the rod mill.

Wire Drawing Equipment.

It can truthfully be stated that little or no progress had been made for many years in the principles of wire drawing machinery, for while there have been some refinements in design, it is at the same time equally true that the fundamentals have been unchanged.

It is therefore a matter of very general interest that the wire drawing equipment of this new plant will represent a very great and forward step in the development of this class of machinery. The finer guages will be produced by means of the Morgan-Connor continuous machines, an English invention which in recent years has been more fully developed and refined in this country.

Many efforts have previously been made to successfully draw wire continuously from the rod to the more finer gauges of finished sizes, but in not a single instance have such efforts met with any degree of commercial success. The basic reason for failure was, in every case, the same. Slippage around the drum and mechanical compensating features were invariably used and always with the same disappointing result.

It would make too long and too sad a story in an article of this kind to attempt to describe just how disastrous these efforts have heretofore proved. The Morgan-Connor system is unlike any previous method for the reason that the idea of slippage is entirely eliminated and the compensation for irregularities is effectively provided for by the fact that each drum in the train serves as a magazine to either pay off, or take on the wire as may be required by the companion drum.

Individual Motor Driven Blocks:

The coarse wire blocks or what in wire mill vernacular are known as "ripping blocks," are also of an entirely new and improved design. Instead of the blocks being driven in groups from one large motor, each drum is provided with its own individual motor. Reliance type and heavy duty adjustable speed motors are being used for this drive. The advantages of this arrangement are almost too numerous to describe here.

One of the "nightmares" of the wire business has been the expense and constant annoyance of breaking in inexperienced help. This, without question, has been due primarily to the hazard of the quick starting drum, which has always been very whimsical and erratic during the starting period.

For many years it has been the ambition of designers of wire drawing machinery to produce a slow starting block—one that not only starts slowly, but which continues in its slow rotation until everything is working smoothly and thus permit the operator to accelerate at will, the speed of the drum and to proceed with such acceleration until physical limitations have been reached. With this new individual motor driven block it is possible, by means of a conveniently located electric control, to actually start the block at four (4) rpm. and to continue at this slow speed just as long as may be required for a smooth and successful start, after which by a further manipulation of the control, the drum may be gradually brought up to almost any desired maximum speed.

There is an entire absence of cams, clutches, pulling-in devices, and other accessories which have heretofore not only been indispensable, but which have also always been looked upon as necessary evils and adjuncts.

Briefly stated, this individual motor driven wire drawing system offers the following advantages:

First—Electric safety features supplemented by dynamic breaking which offers safety advantages which cannot possibly be attained mechanically.

Second—The ease with which inexperienced help may be broken in.

Third—Slow starting, which eliminates many troubles that have heretofore always been present in previous designs.

Fourth—Variable speed which permits the operator to adjust the speed of each individual drum to meet with maximum efficiency the special requirements of the work that is being performed.

Nail Mill.

The nail mill is provided with an initial equipment of 136 machines, mostly of the Tiffin type, which number can be almost doubled, if required. An improved method of anchorage for these machines has been provided so that a re-grouping of the sets, or a re-spacing of the machines can at a later time be most conveniently made, for the reason that the foundation scheme is of a continuous design, which permits of almost unlimited flexibility, in any revision of arrangement which might later be desired.

The nails are conveyed to the polishing barrels by means of an overhead electrical crane, which lands the containers on a mezzanine floor, where they may be conveniently charged into the tumblers with the least amount of manual labor.

The polishing barrels which are of twenty-five (25) keg capacity, are of an entirely new design, all being individually motor driven, the power being transmitted by means of worm gearing. Each polishing barrel is provided with shaking mechanism, which means that the smallest possible size keg or container will be used. This is in line with the modern tendency in this regard.

After packing, the nails are stored, or shipped, by means of automatic conveyors which travel the full length of the nail warehouse.

Galvanizing Department.

The galvanizing department will at first be equipped with two 36 wire galvanizing units. Room has been provided for a third unit to be added later and as intimated previously in this article, the galvanizing department can be still further extended to meet future commercial demands.

The galvanizing take-up frames will be controlled by an electrical variable speed device which gives the supervisor a greater range of speed than has heretofore been possible, even with the modern variable speed motors; a range of from one to 10 may be had without the employment of electrical resistors or gear transmission or without interruption in the galvanizing process.

Fence Department.

The barb fence department will be equipped with 36 barb wire machines, thus enabling the company to furnish practically any type of barb wire. At a later time there will be a number of field fence weaving machines added.

Shops and Accessory Departments.

A thoroughly modern and adequate machine shop has been provided and is being used at this time for considerable construction work. This is supplemented by a carpenter, pipe and forge shops. A supply department is also conveniently located in the center of the plant.

Two 500 hp. Connelly boilers are provided for pickling, heating, gas-producer, and other steam requisites. The bolers are equipped with stokers of the Riley type.

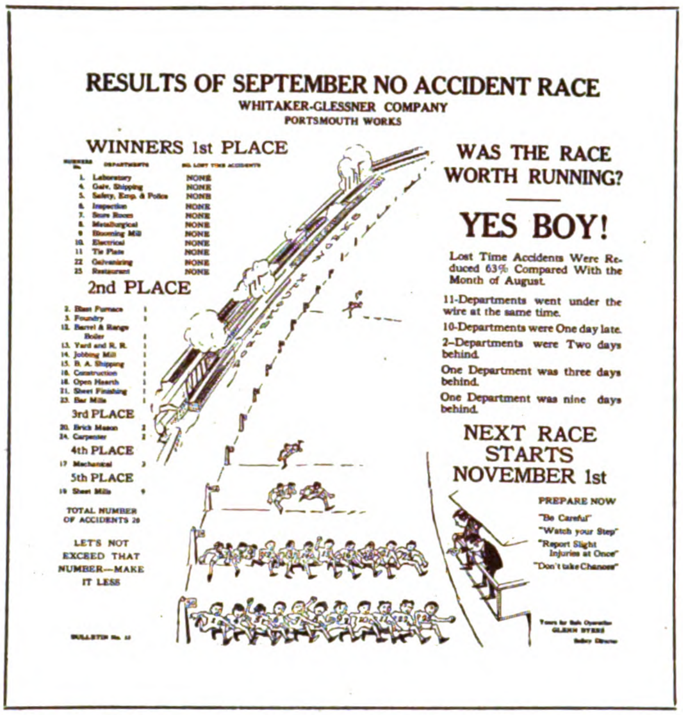
Morgan gas producers provide the fuel for the rod mill.

Feed Water Improvement.

The first consideration in the successful operation of a steel plant is an adequate power supply, and the very first consideration in the successful, uninterrupted operation of the power houses of that steel plant must be the water fed to the boilers for steam generation.

This factor at Portsmouth has received the important consideration it deserves, as is shown by the recently installed purification plant which supplies the entire makeup for all boilers.

The International Water Softener now in operation is a cold continuous, lime-soda, coagulate process in combination with large sand filter bed capacity. Its operation is very nearly automatic and the resultant product is clear carbonate water of about 3-4 grains per gallon hardness as compared to a highly bicarbonate raw water, often free sulphate water with high organic content, with dangerous seasonal changes, which characterizes the flow of the Ohio River at this point. Such a feed supply insures a minimum of power troubles.



RESULTS OF SEPTEMBER NO ACCIDENT RACE

WHITAKER-GLESSNER COMPANY
PORTSMOUTH WORKS

WINNERS 1st PLACE

Numbers No.	Departments	No. Lost Time Accidents
1.	Laboratory	NONE
4.	Galv. Shipping	NONE
5.	Safety, Emp. & Police	NONE
6.	Inspection	NONE
7.	Store Rooms	NONE
8.	Metallurgical	NONE
9	Blooming Mill	NONE
10.	Electrical	NONE
11	Tin Plate	NONE
22	Galvanizing	NONE
25	Restaurant	NONE

2nd PLACE

2.	Blast Furnace	1
3.	Foundry	1
12.	Barrel & Range Boiler	1
13.	Yard and R. R.	1
14.	Jobbing Mill	1
15.	B. A. Shipping	1
16.	Construction	1
18.	Open Hearth	1
21.	Sheet Finishing	1
23.	Bar Mills	1

3rd PLACE

20.	Brick Mason	2
24.	Carpenter	2

4th PLACE

17	Mechanical	3

5th PLACE

19	Sheet Mills	9

TOTAL NUMBER OF ACCIDENTS 26

LET'S NOT EXCEED THAT NUMBER—MAKE IT LESS

WAS THE RACE WORTH RUNNING?

YES BOY!

Lost Time Accidents Were Reduced 63% Compared With the Month of August.

11-Departments went under the wire at the same time.

10-Departments were One day late.

2-Departments were Two days behind.

One Department was three days behind.

One Department was nine days behind.

NEXT RACE STARTS NOVEMBER 1st

PREPARE NOW

"Be Careful"
"Watch your Step"
"Report Slight Injuries at Once"
"Don't take Chances"

Fig. 15—Safety poster. Typical of those used in every monthly safety drive. These posters are 14 x 18 inches and represent very adequately the spirit of these monthly campaigns.

Power.

Space forbids a detailed analysis of the power scheme at Portsmouth although the total layout is so well balanced that it merits a fuller discussion.

In general, steam generation has been limited to a small number of efficient plants, live steam is used at a minimum of necessary points, such as gas producers, boiler feeders, turbine and vacuum pumps, on mill rolls, etc., as well as a limited number of mill engine drives, while turbo-generators and turbo-blowers utilize the heat recoveries from blast furnace gases to the utmost. The overall cost of power must compare favorably with any modern steel plant.

The central station located at the blast furnace includes one 10,000-kw. Westinghouse turbo-generator operating on 200-lb., 100 deg. superheat steam, generating three-phaze, 60-cycle current at 11,000 volts. Two 3000-kw., General Electric turbo-generators at 2200 volts, also two 750-kw., General Electric turbo-generators at 2200 volts.

Main transmission lines lead to the main transformer station, which incidentally is a model of accessibility, safety and permanency. Here three 4200-kva., single-phaze transformers step down to 2200 volts, and one 1500-kw. General Electric motor generator set operating at 540 rpm, converts to 250 volts. This handles the normal mill load.

A substation at the sheet mill with two 3000-kw. motor generator sets and one 750-kw., 2200-250-volt motor generator set operates in parallel with the main station.

A new substation is being built to handle the rod and wire mill load.

This consists of one 3000-kw. and two 1500-kw. motor generator sets.

An interesting feature is the motor driven main pump house which consists of four 500-hp., 2200-volt General Electric motors direct connected to 20,000,000 gallon DeLaval centrifugal pumps.

The total load on the central station averages about 10,000 kw. which with the new wire mills will increase to about 15,000 kw., while the total connected dc. load is about 16,500 hp. and the total connected ac. load about 18,000 hp.

No plant discription can be complete without some mention of the "mental dynamoes," which cause it to function.

Personnel.

It is just as true today, as it was when hand workings were the only known methods of making steel that it takes men to make steel. Today the modern mill or group of mills provide the most remarkable series of specialized equipment and devices that the mind of inventive man can imagine, designed primarily with several thoughts in view, to increase tonnage, to reduce labor, to compete in costs.

Men who can and will subordinate themselves to an organization's needs, and no industrial organization is more exacting than those of the steel industry, still dominate where huge tonnages are evolved. There are two distinct types of mill organizations, the older self developing, self sufficient type where progress is largely a result of frictional contact and internal comparisons and the newer, assembled organization, expanding by the absorption of external elements, men who have gained their variety of hard experiences under various older organizations, and who have learned to progress through harmony rather than friction, and to whom external comparisons are a matter of knowledge.

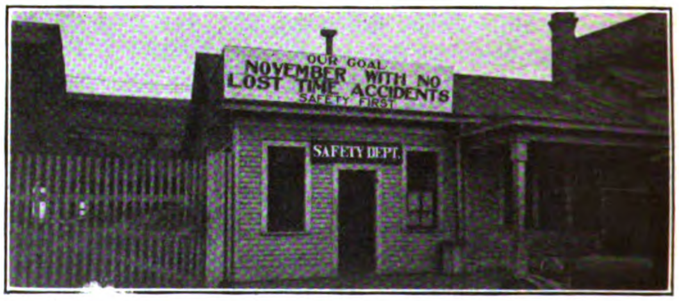


Fig. 16—[illegible] employment office decorated with "Safety." The first impression made upon a new employee or a visitor is striking and lasting.

Of the latter type is the organization at Portsmouth:

George W. Moore, General Superintendent, formerly of Worth Bros. and Lackawanna Steel; Brad. Wheeler, Assistant General Superintendent, formerly of

Minnesota Steel and Homestead Steel; W. H. Chandler, Chief Engineer, formerly of Midvale Steel and Wheeling M. & F. Company; H. E. Engle, Superintendent, Blooming and Bar Mills, formerly of Lackawanna Steel and Milliken Brothers; Robert Cullen, Superintendent, Open Hearth, formerly of Carnegie Steel Company; George Paff, Superintendent, Rod and Wire Division, formerly of Carnegie Steel Company, Sharon, Pa.; W. J. Cook, General Superintendent of Galvanizing of the Wheeling Steel Corporation; H. C. Mosley, Electrical Engineer, of the Wheeling Steel Corporation.

Back of these is seen and felt the constructive influence of W. J. Stoop, formerly general superintendent, now vice-president of the Wheeling Steel Corporation and his able staff of engineering and operating assistants. Progressive steel executives are notoriously broad in their viewpoints, experiences and knowledge of human relationships. Mr. Stoop is one of the few steel men whose actual experience comprehends the design and building of a great steel mill, the selection of the best for the purpose, from among the many alternative equipment combinations, the putting into operation of this equipment and the selective sense to gather an exceptional personnel who can and will maintain the operation on a plane of high efficiency c[illegible]d with low competitive costs.

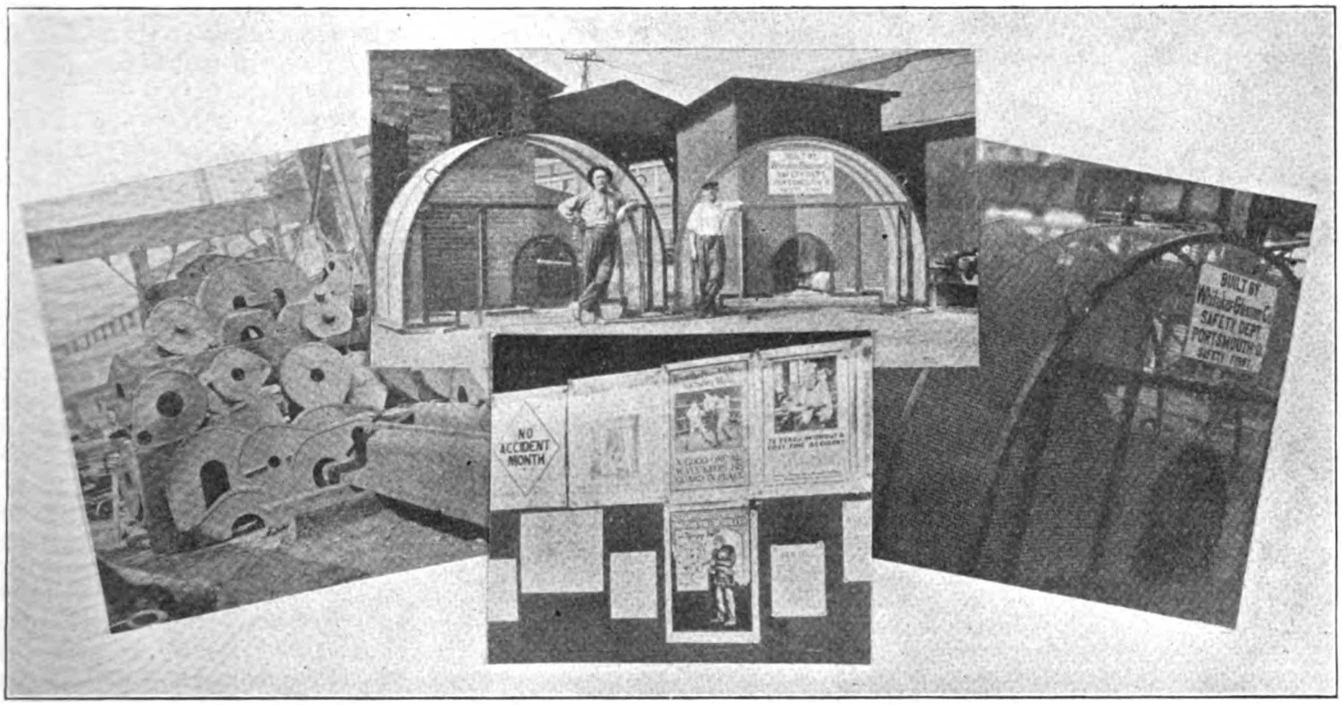


Fig. 17—A safety combination. The bulletin board shown at bottom center is one of five located at the main gates. The other views show safety shields, screens and covers built by the employees themselves. Every dangerous point is covered.

Accident Prevention.

Safety deserves first place in a plant description—but final emphasis is more lasting in a plant description. The methods adopted at Portsmouth to establish the morale which alone can achieve the much discussed and devoutly to be wished "safe plant operation," are interesting.

Portsmouth has done things and may well feel proud.

Just how these results have been accomplished is suggested by the accompanying figures.

The actual procedure is definite, organized and inspired by faith in maximum possibilities to be won only by hard effort.

Accident prevention is a living part of the plant operation.

Accident Prevention at Portsmouth Works Whitaken-Glessner Company.

This company, like many others, for a long time devoted most of the time to installing guards on dangrous parts of machinery. When that work had progressed to the extent that practically every danger had been eliminated, it became apparent that it would be necessary to educate the workers to work safely, because mechanical guards alone, would not prevent all accidents.

Mechanical guards are very necessary in accident prevention, however, the real and best preventative method is education. They are now devoting practically all of their time to educating the worker, foreman and superintendent along the lines of safe operation.

The following is an outline of what is being done to keep safety before the employees:

Accidents are preventable. Those three words are continually brought to the attention of every employee from laborer to superintendent.

Mechanical Guards: At present every piece of machinery has all dangerous parts guarded. The enclosed pictures will give some idea as to what has been done and what is being done in the way of mechanical guards. The management has been, and is now, very liberal with appropriations for this work.

Employment: Every employee hired is handed and told to read a bulletin known as General Plant Instruction. If the employee is unable to read, the employment clerk reads the instructions to him. All foremen are instructed to give new men instructions how to do their work safety, to inform them of the hazards connected with the work, etc.

Bulletins and Bulletin Boards: The attached picture shows large bulletin board located at main entrance (both sides are alike). The bulletins on this board are changed once each week. In addition to large bulletin boards at each of the five entrances, there are 80 small boards. A bulletin covering each lost-time accident is issuerd, which contains the following information: Name of injured employee, his department, occupation, length of service, date and hour of accident, his statement of how the accident occurred, the expected length of disability, the amount of money he will lose on account of being disabled and an explanation of how the accident could have been prevented. This bulletin is posted on bulletin board located next to our Accident Score Board, on which is shown the number of lost time accidents. Each week they are removed and started through the plant. The Accident Score Board is quite an attraction. Practically all of the men look at it each day to see if their department has had a lost time accident. The board is located at the main entrance (picture o fboard inclosed). It shows each department the number of accidents the previous month and the number to date during the present month. Each day a department operates without having a lost time accident, a peg is moved up one notch. If a lost time accident occurs, the peg is moved back one notch.

Fig. 18—A view of a nearby residential street. Comfortable inexpensive home facilities assure a fine mental attitude among the satisfied employees.

Each month an Accident Statement is issued showing the standing of the departments (copy attached), a calendar bulletin and a special appeal bulletin. These bulletins are posted in conspicuous places throughout the plant, on walls, posts, lockers, etc.

A daily report is made to each superintendent, showing the name of each man injured in his department during the previous day. This report also shows the place and cause of accident and nature of injury and name of foreman. The report enables the superintendent to check up on the number of accidents in his department and to investigate them through his foremen. A copy of this report is sent to the general manager

Safety Meetings and Safety Committees.

Central Safety Committee. The Central Safety Committee is composed of department superintendents or general foremen, the general manager is chairman and the safety director is secretary. The committee meets once each month.

Departmental Committees: There are 20 departmental safety committees, the membership ranging from five to 21 according to the size of the department. These committees meet once each week to discuss safety conditions in their respective departments. The superintendent of the department is chairman and he appoints the members. The employees are requested to offer their suggestions to members of the committees, who are instructed to present them at the next meeting and to advise the employee of its disposition.

Employees' Representatives' Committee: This committee is composed of three men, elected by the employees. The committee meets once each month with three men appointed by the management, to make inspections and recommendations.

Group Meetings: The safety director and safety inspector hold small group meetings each day, talking to 10 to 25 men at each meeting. These small group meetings are more effective than general meetings. At these meetings, the hazards these particular men are exposed to are talked over, ie., if to brick mason laborers, the men are cautioned to watch out for bricks coming dow nthe chute, the safe way to remove a brick from a chute, etc., etc.

Inspections: There is one full time safety inspector, who checks up on conditions of safe guards now installed and makes recommendations for new safe guards, where necessary.

Each month, all foremen are required to send a report to their superintendent, covering safety conditions in their department. At the monthly meeting of the Central Safety Committee, the recommendations are acted upon and the foremen advised of disposition.

Statistics: Accident frequency and severity is figured as follows:

Frequency—Accidents per 1000-300 day workers.
Severity—Days lost per 300 day worker.

The scale of time losses for deaths and permanent disabilities is used as adopted by the National Safety Council and advocated by the International Association of Industrial Accident Boards and Commissions and by the United States Bureau of Labor Statistics. (Death 6000 days: Loss of finger, 300 days, etc.)

During the year of 1921, the frequency rate averaged 223.78 per month and the Severity rate averaged 3.96. The Severity rate does not include any permanent disability charges.

This reduction in frequency and severity was accomplished by getting the co-operation of everybody in the plant. Special bulletins and personal and group talks were used to reach the workers and special letters and meetings to reach the foremen. Everlastingly keeping at it will get results and it is hoped to reach our goal, a "No Lost Time Assident" month within the next four months.

Per Month	1921	Jan. 1 - Aug. 31, 1922	Sept. and Oct. 1922
Frequency	223.78	272.39	101.08
Severity	3.96	3.91	2.47

The exceptional reduction shown during September and October, 1922, was the result of a special drive.

Fig. 15 shows a typical monthly poster used in this drive.

Figs. 16, 17, 18 and 19 are self explanatory.

Foreign Blooming Mill Practice*

A Series of Production Studies to Determine the Proper Number of Passes. Cooling Due to Roll Contact Rather than Time Intervals. Power Requirements at Various Reductions Does Not Vary Greatly.

By. DR. C. KIESSELBACH

I WILL not deliver a complete treatise on the rolling of ingots, but only make a few remarks criticizing questionable proceedings, under different methods of driving. The development of rolling mills is under the influence of the steel manufacturers, who with the large demand for steel put great stress on the ability to pour the largest and heaviest ingots. The increased demands should influence the existing or new driving means to be built. With this object in view I have compared the conditions of a large number of rolling mills with old and new drives, be it by steam or electricity, and give the results, as far as I am permitted to make public, to stimulate further investigation.

The first fact, which came to my notice, was that the number of passes, which are used by various mills to do the same rolling work, showed unthought of differences. In order to give a clear idea of this, I have taken as a means of comparison, rolling which can be carried out at a large number of mills, namely, the rolling of 500 mm. cross-section to 130 with ordinary material. Table I gives the information on this. There are given four plants using steampower, D I-D IV (with duplextandem-reversing engines) and four plants with electric power, E I- E IV. In column four of the table can be seen that the necessary number of passes varies from 15 to 29, almost 100 per cent. Column five gives the average elongation per pass. It decreased from 20.3 per cent with D I to 9.8 per cent with E IV. The effective diameter in the first pass varied from 674 to 889 mm. according to the gripping power.

According to the work of Bronot, "Das Kalibrieren der Walzen," it was necessary to make 21 passes with the early cogging rolls using steam engines now obsolete, for an average elongation of 13.7 per cent.

Figs. 1 and 2 show roll drawings similiar to those at plant D II and D IV, Fig. 3 goes with D III, Fig. 4 with E I, Fig. 5 with E II, and Fig. 6 with E III.

Roll Design.

The grooves of Fig. 6 demand particular attention. Ingots of 600 mm. sq. cross section can be rolled this way with comparatively small drawing through power (gripping). Hence it follows that the rolls must have a small diameter and also that the roll length be short for stiffness. There are only five passes instead of the usual arranged six and the narrow flat pass is put in the center, in this way the roll is weakened the least. The collars between the passes are moderately narrow and the side walls are strongly inclined, about 10 per cent. In the first pass the ingot can be reduced to 240 mm. But as the second pass has a width of 278 mm. it does not have to be reduced so far. In reality the bloom enters the second pass at 260 mm. after it was passed 14 times through the first and only edged once. The otherwise customary forming is mostly so that one must totally guide the rolling together, in order to be able to go into the next pass by turning. This does not seem very practical to me, because it follows, that one must make two passes with very slight reduction or one empty pass, in order to arrive at this necessary goal. I would like to state that I think it is advisable to make a very large reduction in the first pass. One can then press strongly in spite of the ingot still being very broad. In the last passes it is not always possible to make use of the full gripping power, because the size of the pass is small, but at the same time the diameter of the rolls are not increased much, so by this means a certain equalization takes place.

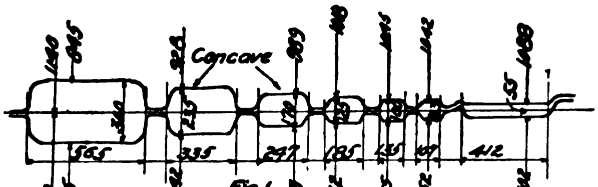


Fig. 1

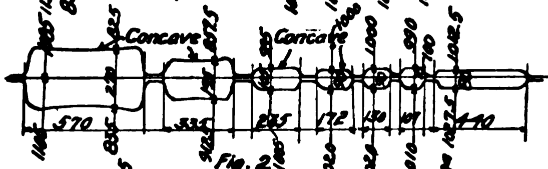


Fig. 2

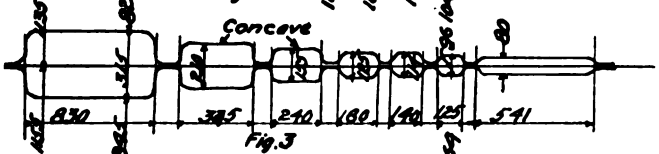


Fig. 3

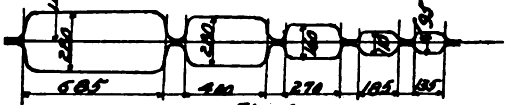


Fig. 4

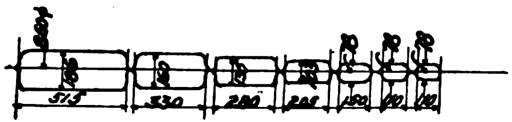


Fig. 5

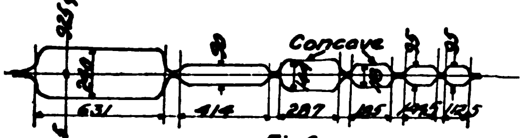


Fig. 6

There is always a considerable excess with strongly

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*From Stahl & Eisen, January 15, 1920. Translated by R. Rimbach.

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TABLE I. NUMBER OF PASSES AND THE ROLLING WORK WITH INGOT ROLLING

Designtaion of the Plant	Diameter of the Rolls in mm.	Diameter of First Form in mm.	Number of Passes for Rolling From 500 mm. sq. Cross-Section to 130 mm. sq. Crocc-Section. Elongation 1:14.8	Average Elongation Per Pass %	Remarks.
D I	1150-1200	830-880	15	20.3	Beginning with 520 mm. sq. cross-section.
D II	1100	785-800	17	17.3	
D III	1140	835	17	17.3	
D IV	1100	840	17	17.3	See: "Weitere Versuche zur Ermittlung des Kraftbedorfs au Walzwerken" by Dr. Puppe, Dusseldorf, 1910.
E I	1150	860	23	12.4	
E II	860	674	26	10.7	Rolled to 118x150. See: "Versuche zur Ermittlung des Kraftbedorfs au Walzwerken" by Dr. Puppe, Dusseldorf, 1909.
E III	925	690	28	10.2	Rolled to 120x137.
E IV	1100	790	29	9.8	

To roll from 600 mm. sq. cross-section to 130 mm. sq. cross-section D I takes 19 passes, average elongation per pass 17.4% (Hard Steel)
To roll from 600 mm. sq. cross-section to 130 mm. sq. cross-section D II takes 21 passes, average elongation per pass 15.7%
To roll from 580 mm. sq. cross-section to 122 mm. sq. cross-section D III takes 21 passes, average elongation per pass 16 %
To roll from 550x585 mm. sq. cross-section to 130 mm. sq. cross-section E I takes 27 passes, average elongation per'pass 11.5% (Cast Steel)
To roll from 600 mm. sq. cross-section to 120x137 mm. sq. cross-section E III takes 133 passes, average elongation per pass 9.9%

built driving machines so that one can press considerably in the last passes. For example with D III the elongation in the next to the last pass rises to 44 per cent.

Production Is Inversely Proportioned to Number of Passes.

In what measure the production per hour depends on number of passes, is shown by two examples which Dr. Ing. Puppe has published. In the first case (EII) 2675 kg. ingots of 500 mm. sq. cross-section are increased to 10 times the original length in 23 passes, in the second example (D IV) 2640 kg. ingots of 500 mm. sq. cross-section are rolled in 15 to 18 passes from 8 to 11.247 times the original length, or an average of 9.62 times. If one subtracts the accidental pauses in all cases and adds five seconds interval between two ingots as the least necessary pause, so with 23 passes with wholly undisturbed running the calculations give 46.55 tons and with 15 to 17 passes give 71.5 to 60 tons, an average 65.7. From this one concludes that the production is inversely proportional to the number of passes.

It will not always be quite so bad, because there is comparatively less turning and pushing with slight reductions.

The rolling mill D I is able, to reach the above production with 11 to 13 passes instead of 15 to 17. It is interesting to study how the production would change if the gripping power of D L V was changed by making the driving pinion as large as D I without increasing the steam engines. According to the figures of Dr. Ing. Puppe the actual time of a pass in the case of D IV, that is the time that the ingot is between the rolls, equals 41.42 seconds the interval time equals 107.3 seconds. If now with the changed pinion we make 11 passes instead of 15, the actual time of pass remains unchanged on account of the retarded pulling through, but the interval time is reduced, on account of the number of passes, to 78.8 seconds, total time 119.2 seconds. This gives an increase in production of 20 per cent. One can see from this, that large transformation gears will serve the purpose if it is a question of large cross-sections. It is totally different in most plants of medium size where blooms 60 mm. sq. are turned out on the rolling table in a second roll housing, because one can depend on greater speed of passing through the rolls.

Size of Ingots Important.

In order to roll out 600 mm. sq. cross-section to 130 mm. sq. cross-section, E II requires 33 passes, E I 27 passes, D II 21 and D I makes it comfortably in 19 passes. Calculating 1,000 ton production a 4,800 kg. ingot weight gives 6,875, 5,625, 4,375 and 3,920 passes respectively. If one roll 500 mm. sq. cross-section ingots each weighing 2,600 kg., E IV needs 29 passes, E I 23 passes, E II 17 and D I 15 passes, which in the case of 1,000-ton production corresponds to 11,150, 8,850, 6,540 and 5,770 passes respectively. From the point of view of cost of work it is naturally practical to pour the heavy ingots as long as possible. E I goes the furthest along this line. The ingots are 460x495 on top and 550/585 bottom and weigh 5,500 kg. and are about 2,600 mm. long. To roll 1,000 tons 4,900 turns are necessary. Mill D I would need 17 passes and 3,090 revolutions. If one pictures the amount of machinery and mechanism which must be put into use in each revolution, and that each revolution on account of the speed and delays is coupled with mechanical losses, one will understand what such great differences mean and how important the gripping power is in the rolling of large ingots. In actual practice, experience shows, that one and the same rolling mill reaches a larger production with heavy ingots, in spite of the large number of passes for each ingot.

Heat Losses.

The question of the cooling off of the rolled material is essential; not only on account of connection with the use of power and wearing out of the rolls, but also on account of the demand that the bloomed material be finished in a second rolling mill without reheating. Many times and especially with heavy ingots it is necessary to cut the bloom into two and sometime even three parts between the blooming mill and finishing mill. The smaller the number of passes and therefore the time of

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rolling, the less the cooling. But the publications made up to the present by Dr. Ing. Puppe give no reason for stating that the cooling is proportional to the cooling off time. According to Dr. Ing. Puppe the temperature of D IV falls from 1,170 to 1,163 deg. from the third to the thirteenth pass, that is only 7 deg. and then stays at that temperature to the end, the fifteenth pass. The total rolling time amounts to 149 seconds; the ingot was rolled fast in the ordinary manner. With the other ingots they were in the most cases purposely rolled slowly, 173 to 207 seconds rolling time and the drop in temperature amounted altogether to 14 deg. with starting temperature of from 1,207 to 1,165 deg. In all cases there was no further cooling in the last few passes. The elongations were from 7.27 to 11.25 times. But with E II according to Dr. Ing. Puppe the temperatures drop with elongations 9.8 to 10 times in 23 passes from the third to the last pass, or from 50 to 64 deg., or about four times as much as above. The rolling times were 207 to 254 seconds; they were therefore not much larger due to the intentional retardation in the first example; they give no explanation for the considerably increased cooling. One, therefore suspects the number of passes, or, what means the same, the size of the reduction-coefficients play an important part. The explanation probably lies in the fact that with the larger number of passes the material is in contact with the cold rolls for a greater length of time. If this is the only reason it is undecided. If with greater pressure a comparatively greater transformation of work into heat takes place, therefore this would be the only explanation for the slight cooling off. One could fear an unfavorable influence on the power requirements. I have looked through the experimental figures of Dr. Ing. Puppe with this object in view. In Tables 51 and 52 of Puppe, one finds on line 21 the relation of displaced volume to the real rolling work. The figures given there are nothing more than the displaced number of cubic millimeters per kilogram meter of rolled material produced. From the same table of figures the obtained elongation can be calculated from the given rolling cross-sections for each pass. In Figs. 7 and 8 are given the displaced cubic millimeters per working unit from line 21, also it shows a remarkable agreement in the course of both diagrams. The rises and depressions follow almost regularly and at the same time. Even with continued elongation and especially with rolling of shapes there is no longer a similiarity of the diagrams, one will have to admit, the appearance is a remarkable one, but one can hardly take the coincidence for granted. If one should pronounce a law on this, it would read: with increasing reduction coefficients the specific consumption of work decreases, or: the work of driving is used better, the more one presses. Probably the fear, expressed above regarding the heating up, because of strong pressures may be for the power consumption ungrounded.

The Value of Gears.

All the rolling mills with steam power (D I-D IV) mentioned in the table have driving pinions, gearing 1:2 to 1:2.5. The electrically driven plants (E I to E IV) grip directly. From all I have said, can be seen, how useful a powerful gearing can be. It still remains to be investigated if it is not perhaps that the use of large power for its acceleration lessens its usefulness to considerable degree. According to Dr. Ing. Puppe the average number of revolutions per minute of the rolls in the first passes is about 40, later 50 per minute. The total power which must be supplied to all the movable parts in order to obtain 40 revolutions amounts to 90,000 mkg. with normal steam engines geared approximately 1:2.5. From this alone 60,000 mkg. on two wheels of the driving pinion. The machine gives 90,000 mkg. of effective work during half a revolution with an effective average pressure of not quite 1 atmosphere. With the plants, studied here, the receiver steam pressure is raised when not rolling, by this the mechanical power is particularly great with the beginning of work which also does away with the otherwise unavoidable throttling, so that this one atmosphere above the normal demand is always ready as a surplus at the beginning. From this follows, that 40 revolutions are reached without a start at the finish of the first machine hub, that is after 0.2 of a revolution, while at the same time the whole rolling work is supplied. Fifty turns of the rolls is reached with the same pressure after 0.3 of a revolution. Great speed would be possible without anything additional, but it is hardly desired.

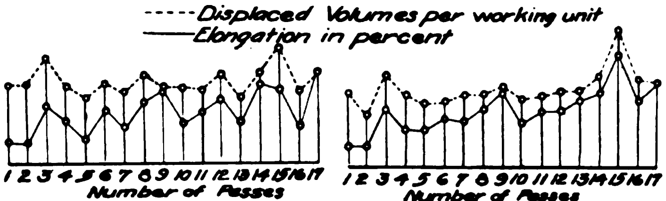

Fig. 7

Fig. 8

Elongation & Displaced Volumes per Working Unit

I have, above, only spoken about ingot-rolling. The conditions for the rolling of sheets are almost the same. The actual times of passes are there also considerably shorter than the intervals and it also holds that more depends on the large pulling through power than the high rolling speed. With the wide universal mills, which, in the reversing mill, is frequently also rolled to great lengths, the matters are somewhat mitigated. Ordinarily the rolls are too long and too thin, to permit a very strong pressure; but it is on this point that I would like to call attention in new proposed universal mills: One should choose the diameter of the rolls comparatively large and prevent the attempts to roll as broad as possible, in the interest of the extended rolling program.

OXWELD OCCUPIES LARGER QUARTERS IN SAN FRANCISCO

The Oxweld Acetylene Company accounces that its Western Department formerly located at 1077 Mission street, San Francisco, has recently moved to larger quarters in the same block. The new address is 1050 Mission street.

The Oxweld Acetylene Company is the largest manufacturer of oxyacetylene apparatus in the world. Its general headquarters is at Newark, N. J., where one of the company's plants is located. In the Western Department the company maintains offices also at Los Angeles, Portland, Seattle ,Salt Lake City and El Paso.

The growth of the Western Department of the Oxweld Acetylene Company is very representative of the growth of the welding and cutting industry as experienced in the country generally and indirectly reflects a general revival of trade and manufacturing.

Chilled Roll Making for Sheet Mills

High State of Development Required to Meet Modern Conditions. A Proposed Explanation of the Breakage of Rolls.

By. W. H. MELANEY*

THE manufacture of chilled rolls to be used in the production of sheets is always a precarious and more or less uncertain proposition, due to the many unforseen conditions that must be met, even in the manufacture of such rolls as are used to produce ordinary black sheets. These conditions become much more difficult when applied to the making of rolls for the rolling of automobile sheets that will meet the exacting requirements insisted on by automobile manufacturers of today.

Not only must the rolls be free from any imperfections such as pin holes or grey specks on any portion of the rolling surface of the roll but the entire surface must be of such character as to produce a perfect finish on the sheets free from any gathering or roughness. To produce a roll of this type requires the same care and expertness that is necessary in making chilled rolls for rolling sheet copper or brass with the added qualification that these rolls must keep their surface and stand up under conditions that would put the rolls used for rolling sheet copper or brass out of commission. This is the problem that the modern roll manufacturer has had to solve in the production of rolls suitable for the rolling of high class auto sheets and has resulted in the production of a type of roll eminently superior to anything previously produced for sheet or tin mill purposes.

The making of chilled rolls of this type is one of the most difficult problems the foundryman has had to contend with. Not only must he watch the chemical composition and keep it within comparatively close limits but the physical conditions must also be closely guarded. A roll may be perfect so far as its chemical composition goes and still break within a few hours after being placed in service, while on the other hand a roll the analysis of which is greatly at variance with all preconceived ideas of what should constitute the proper analysis for this type of roll, may wear out in service. This is due to the physical conditions under which the two rolls were either produced or operated. In many instances two rolls cast from the same ladle of metal of identical composition and cast so far as discernible under exactly similar conditions, go into service at the same time. One gives excellent service, the other is a complete failure due to some physical condition that existed in the one roll but failed to make itself manifest and which may have resulted from some slight difference in treatment either before or after being placed in service. The uncertainty of the exact cause for the breakage of sheet and tin mill rolls is so universally recognized by both the user and the maker that it has been mutually agreed between them that unless the roll shows some visible defect after breaking it is to be considered a good delivery.

Many users of rolls insist on specifying just the type of roll they prefer based perhaps on the particular practice in vogue at their plant. Others again leave it up to the roll maker to furnish a roll that in his judgment will best meet the conditions under which the roll is to operate. All of them however are insistent in specifying the particular depth of chill they prefer and which in their judgment is best suited to their requirements.

When it is known that no one type of roll will best fill the conditions under which different classes of sheets are rolled, it is apparent that the roll maker with his expert knowledge of roll making and the peculiarities incident to each particular type, backed up with years of experience in supplying rolls to hundreds of different users, should be the one best able to decide.

As it is generally conceded that roll breakage is primarily due to heat conditions no tests such as the tensile test or the transverse test, as usually applied to cast iron, is of very much consequence in chilled roll making. Rather the physical characteristics such as hardness of face, clearly defined crystalline structure, or the reverse of this, interlacing of the depth of the spray in proportion to the clear chill, depth of chill on rolls used to produce different products, coefficient of expansion, and whether rolls are to be used hot or cold are important. These should be the determining factors in selecting the type of roll best suited to the prevailing conditions. These are properties with which the user of chilled rolls rarely concerns himself while the maker if he be skilled in his art is in constant touch.

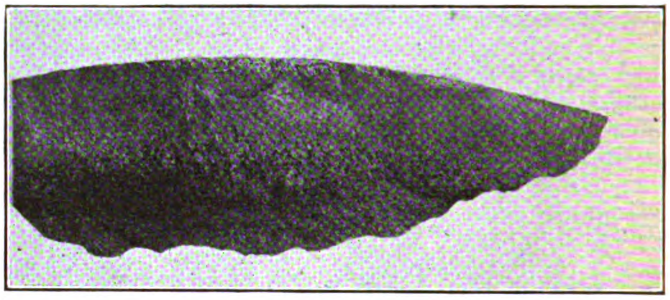

Fig. 1—A type of roll in which the crystals are not sharply defined.

Therefore it would seem to be the better part of wisdom to state the kind of sheet to be produced and the conditions under which the rolls must operate and then leave it to the maker to furnish the type of roll required.

A roll that would be ideal for the average tin mill would make a very poor showing on auto sheets, and one that would give superior surface when used as a cold roll could not be kept in service many hours when used as a hot roll before going to pieces. Then again a roll that might produce satisfactory common black or galvanized sheets could not be used at all on either of the other products.

The writer will endeavor to show the logic of these statements and by the illustrations indicate the particular type of roll best suited to the various uses mentioned above.

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*National Roll & Foundry Company, Avonmore, Pa.

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Fig. 1 illustrates a type of chill in which the crystals are not sharply defined being rather of a matte texture. This roll while giving a fair surface is but slightly affected by heat conditions, therefore it is less liable to break in warming up as it has a low coefficient of expansion. It would not give the surface required for auto sheets.

Fig. 2 represents a chill showing a sharply defined crystal fairly sensitive to heat with a high coefficient of expansion and while more susceptible to breakage will give the smooth finished surface required to produce high grade sheets.

Fig. 3 is a typical chill fracture for a cold roll showing glittering sharp crystals, with a high coefficient of expansion. As these rolls are subjected to very little heat they are fairly safe from breakage when properly handled and will give the highly finished surface necessary to cold roll high grade sheets without leaving tail marks, but could not be used as a hot roll without going to pieces. These statements are based on the assumption that all the other physical conditions in each class of roll are similar and that the usual conditions of service as generally found in the mills are used.

The breakage of chilled rolls because of variations in heat conditions is dependent upon the rapidity with which these changes take place. If extended over a long period of time with a gradual increase of temperature slowly applied until the roll reaches its working temperature the breakage will be reduced to a minimum. This condition is acknowledged by all users of chilled rolls as true.

Yet the exact reason therefore is not so apparent.

The writer while acknowledging that there is no exact data available to show just how this rapid expansion tears these large bodies of solid metal assunder, would suggest the following theory as the probable cause.

Expansion from heat acts differently on various bodies.

In *isotropic* bodies, that is those in which the coefficient of expansion will be the same in every direction, the tendency to rupture from heat is at a minimum as the object gradually increases in volume evenly when heated.

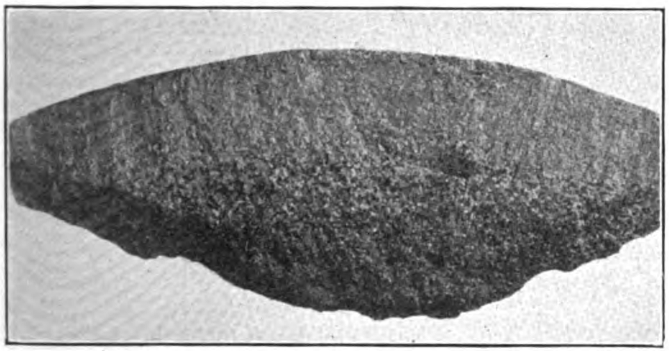


Fig. 2—Sharply defined crystals in a roll indicate a high coefficient of expansion making it susceptible to breakage but give the surface necessary for rolling auto sheets.

Non-isotropic bodies however such as crystals exhibit different physical properties in different directions.

Many crystals showing a vastly different coeffiicient of linear expansion in a direction parallel to their axis than that shown at right angles or perpendicular to their axis.

Now assuming that a chilled roll (which is highly composite structure) if of a non-isotropic or *aeolotropic nature* in the crystalline chilled portion of its exterior and comprises a crystalline band of metal at least ¾ in. thick around the entire rolling surface of the roll, while the granular or unchilled portion of the roll extending through to the center is of an *isotropic nature*.

It does not require a very great stretch of the imagination to see that, when the outer crystalline portion with a coefficient of expansion radically different diametrically from that in a linear direction is rapidly heated before the interior or granular portion is even warm, it should tear itself apart.

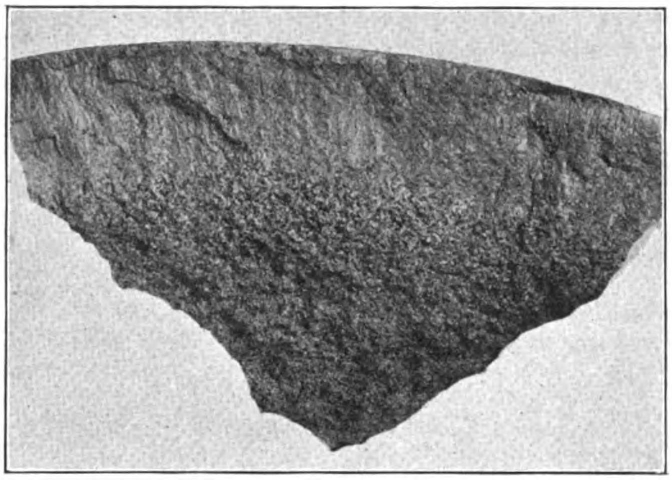


Fig. 3—A typical fracture for a cold roll. As these rolls are not subjected to extreme heat the crystalline structure shown does not cause breakage and gives the desired high finish.

That they do tear themselves apart rather than break in the usual acceptation of this word is apparent when it is shown that the outer or crystalline portion of the roll is often cracked through its entire depth for some time before the granular portion finally lets go.

Perhaps some day our physical research laboratories may investigate this very costly condition and show exactly what takes place and how to avoid the great loss of money and output of product due to the very prevalent breakage of rolls in sheet and tin mills.

The Rochester (N. Y.) Gas & Electric Corporation is preparing to expand its water gas plant, in order to meet the demands of increased consumption. The U. G. I. Contracting Company of Philadelphia has been awarded the contract covering this expansion and will nstall a 12-n. carburetted water gas apparatus, of exceptonal design, to gether with waste heat boiler. The U. G. I. Thermo-Automatic Control will be installed with the apparatus.

The U. G. I. Heavy Oil Nebulizing System which was recently offered to the gas industry by the U. G. I. Contracting Company, of Philadelphia, has been received with approval, according to the orders being received by that company. Recent gas companies to adopt the U. G. I. Heavy Oil Nebulizing System include the Bridgeport (Conn.) Gas Light Company, Malden & Melrose Gas Light Company, Malden, Mass.; Consolidated Gas Electric Lifiht & Power Company of Baltimore, Md., and the Western United Gas & Electric Company, Joliet, Ill.

Recent Interesting Electrical Developments

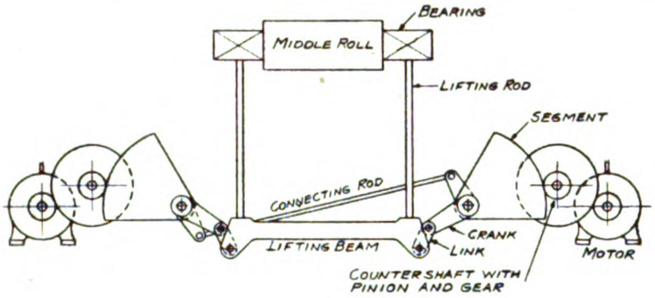
Electric Roll Balance for Lauth Mill—Rod Reel Control—Electric Heating.

By GORDON FOX*

Electric Roll Balance for Lauth Mill—An installation of considerable interest is the electric roll balance installed in connection with the 36x110-in. plate mill of the Dominion Iron & Steel Company at Sydney, Nova Scotia. This is a Lauth mill with electrical balance applied to the middle roll.

The scheme of the mechanism which operates this balance is shown in Fig. 1. Two 150-hp. series mill type motors drive through gear reductions to segmental gears which operate two cranks. These are attached to a lifting beam through links. The lifting beam is located beneath the housings and the middle roll is supported above it by rods which carry the bearings.

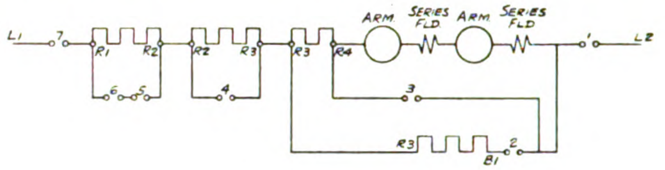
The motors function to elevate the middle roll, to any point within its limit of travel, until it strikes the top roll. The motors then stall and exert a fixed torque to retain the roll in its upper position against the top roll. This action occurs when the master controller is in the "raise" position. When the master is thrown to the "lower" position the lifting torque is relieved and the roll permitted to lower due to its weight. The motors exert a braking effect, however, which restricts the lowering speed. The travel, both raising and lowering, is about 6 in. per second. At the off position of the controller a dynamic braking circuit is maintained which prevents the motor from lowering at excessive speed. This is a self-contained circuit in which the armature current sustains the series field. It is therefore independent of an outside source of power. Should the power fail at any time the middle roll will lower at restricted speed.



SCHEME OF MECHANISM FOR ELECTRIC ROLL BALANCE OF LAUTH MILL

Fig. 1

The principal control connections for this drive are given in Fig. 2. In raising the roll, contactor No. 3 opens and contactors Nos. 1, 4, 5, 6, 7 close, the closure of contactors Nos, 4, 5, 6 being controlled by current limit accelerating relays. When the middle roll strikes the upper roll, a jam relay causes contactor No. 4 to open and insert jam resistance to restrict the torque and current. When the master is thrown to the "lower" position, contactors Nos. 5 and 6 open (after a brief delay) and contactor No. 2 closes, completing a dynamic braking circuit. Contactor No. 3 is a normally closed contactor which closes when the master is thrown to the off position or in case of failure of power. This closes a short dynamic braking contact which prevents the roll from dropping.

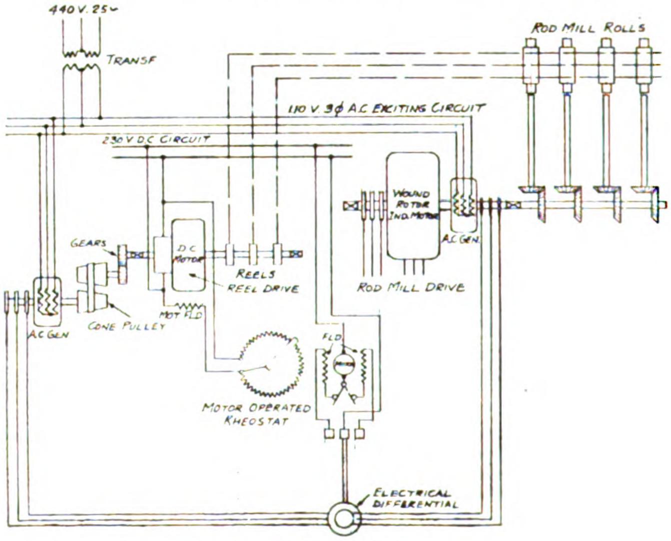


CONTROL CONNECTIONS FOR ELECTRIC ROLL BALANCE OF LAUTH MILL

Fig. 2

Rod Reel Control—The Minnesota Steel Company has recently installed motor driven rod reels equipped with a special control devised to maintain the speed of the reels in step with the delivery speed of the mill at all times. The control is an adaption of that previously applied in connection with the sectional drive of paper machines. The scheme of connections for this control is given in Fig. 3.

The reel is driven by a 100-hp. shunt wound adjustable speed motor. This motor, beside driving the reel, also drives a special small (1-kw.) a.c. generator through an arrangement of change gears and cone pulleys such that the generator can be operated at a given speed regardless of the speed of the reel motor. A similar small



SCHEME OF CONNECTIONS REEL DRIVE FOR ROD MILL

Fig. 3

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*Electrical Engineer, Freyn, Brassert & Company.

a.c. generator is direct driven by the main motor driving the rod mill rolls.

The circuits from the two small generators are brought to the primary and secondary windings, respectively, of a small wound rotor induction motor which constitutes a differential relay. The relations within this small motor are such that when the primary and secondary frequencies correspond (as determined by the speeds of the small generators) no rotation results. If one of the small generators lags behind the other, its frequency decreases and the differential relay is caused to rotate slightly and thereby close contacts which, in turn, actuate a small motor driving a rheostat connected in the field circuit of the rod reel motor. This causes the speed of the reel to change and also re-establishes equilibrium in the differential relay. It has been found possible, with this arrangement, to maintain the speed of the reel motor within 1 per cent.

Electric Heating—Electric heating applications are making steady progress. An annealing installation of interest because of its size is the furnace now in construction at the Keokuk (Iowa) Steel Casting Company. This is a car bottom type furnace of 335-kw. capacity. The furnace is 6 ft. wide, 10 ft. long and 4 ft. high. It will be capable of raising its charge, 10,000 lbs. of steel castings, to 1650 deg. F. in five hours, starting with charge and furnace cold. This is a regenerative type installation with metallic resistors.

The Inland Steel Company have installed an electrically heated tempering furnace which is used for heat treating shear blades and other tools. Shear blades in this furnace are proving decidedly superior to those formerly treated in oil fired furnaces, the life and condition of the blades being greatly improved.

The Inland Steel Company has also applied electric heating to the conditioning of the finishing rolls of their sheet mills prior to the initial turn, thereby largely eliminating the disadvantages incident to the necessity of "warming up" the mills.

Adjustable Speed Motors for Rolling Mills

Carnegie Steel Installed the First Large Motor for Mill-drive in 1905. Direct-current Motors Still Predominate Regardless of Higher Cost and Lower Efficiency than A. C. Systems.

By J. D. WRIGHT*

In the past few years there have been a number of papers written on the subject of adjustable-speed drives for rolling mills and it may be of interest briefly to review the extent to which the various systems have been applied. In the order of their application, six different systems have been used as follows:

1. Direct current motors with adjustable-speed control obtained by varying the field strength of a shunt or compound wound motor taking power from a constant potential source.

2. Direct current motors with adjustable-speed control obtained by the Ward-Leonard system, in which the speed of a shunt or compound wound direct current motor is varied by varying the voltage impressed on the armature; also modifications of this scheme using both generator field control and speed control obtained by varying the strength of the shunt field.

3. Induction motors operating in concatenation. Concatenated motors consist of mechanically connected single-speed or multi-speed induction motors with windings so arranged that the operating speed may be the synchronous speed of either motor or a speed corresponding to the synchronous speed of a motor having a number of poles equal to the sum of the poles of both machines.

4. Changeable pole induction motors providing multi-speed control; these motors may have a single winding so arranged that the number of poles can be changed by changing the arrangement of the windings by means of switches or the motors may have two or more independent windings giving different synchronous speeds.

5. Induction motors with adjustable-speed control by the Kraemer system.

6. Induction motors with adjustable-speed control obtained by the Scherbius system.

Early Installations Were Direct Current.

1. It is interesting to note that the first large rolling mill motors of any type installed in this country were of the adjustable-speed direct-current type. There were two of these motors, each 1,500 hp., installed in 1905 to drive the light rail mill at the Edgar Thompson Works of the Carnegie Steel Company. In general, direct current motors with speed control obtained by varying the strength of the shunt field may be economically applied on mills requiring a driving motor of relatively small horse-power; say 500 hp. or less. They may also be most advantageously applied to mills where extreme accuracy of speed adjustment and regulation is required. The first example of such an installation is the 14 in. continuous hot strip mill at the plant of the Trumbull Steel Company. The mill consists of 10 stands. The first four and stands five and six are driven by two 1,250-hp. 175/350 rpm. 600 volt shunt wound adjustable-speed direct current motors. Each of the last four stands is driven by an 800 hp. shunt wound adjustable-speed direct current motor. Fig. 1 shows the installation of these machines. The motors are operated from a 600-volt constant potential bus fed by two generators of synchronous motor-generator sets. The entire range of motor speeds is obtained by adjustment of the strength of the motor fields. The exacting speed control requirements of this mill, resulting from high rolling speeds, individual drive and close spacing of stands, were most economically met by direct current driving motors.

2. The Ward-Leonard system or a combination of armature voltage and motor field strength control have

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*Engineering Dept., General Elec. Co., Schenectady, N. Y.

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been applied most extensively to direct current motors driving reversing mills. An installation of such a motor for driving the 40 in. reversing blooming mill at the Sparrows Point plant of the Bethlehem Steel Company is shown in Fig. 2. The speed torque characteristics of motors so controlled are ideally suited to blooming mill applications. The motor is essentially a constant torque machine throughout the speed range obtained by generator field control and a constant horse-power machine throughout the speed range obtained by motor field control.

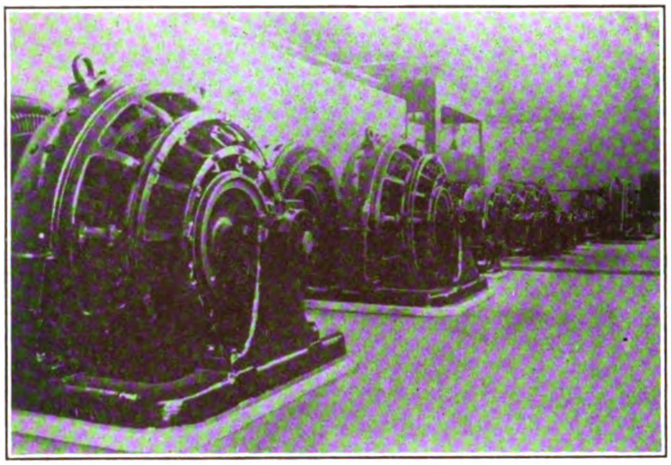

Fig. 1—Motor room 14 in. hot strip mill, Trumbull Steel Co. showing two 2,300 kw. (50°C. rise) 600 V. D. C. generators direct connected to 2,300 V. 60 cycle synchronous motors; 150 kw. exciter; four 800 hp. d.c. motors, and two 1,250 hp. motors.

Ward-Leonard control has also been used in a few cases on structural mill drives where it is desired to enter the steel at a low speed and accelerate to a higher speed during the pass. An example of such a drive is the 6,300 hp. motor for the 28-in. combination rail and structural mill of the Tata Iron and Steel Company. Such drives are, of course, relatively expensive as a motor-generator must be used for obtaining the direct current power. An exciter must also be provided for separate excitation of the generator and motor fields.

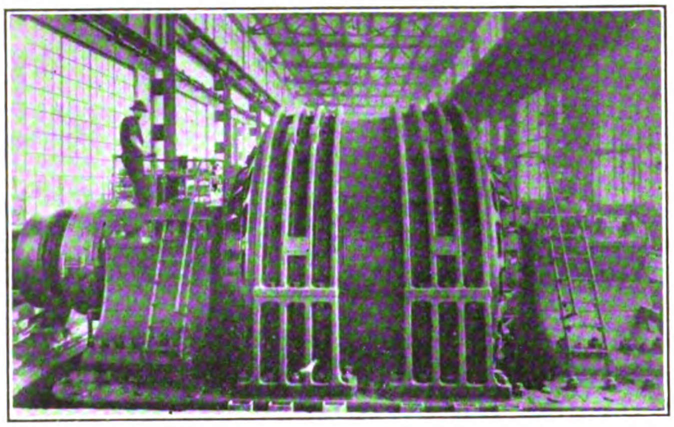

Fig. 2—6,500 hp.-(50°C.)-50/120 rpm.-1,200 V. motor driving 40 in. reversing blooming mill at the plant of the Bethlehem Steel Co., Sparrows Point, Md.

Alternating Current Motors.

3. There have been only three installations of concatenated motors used in the country, two at the South Works of the Illinois Steel Company for driving light rail mill and one at the plant of the Oliver Iron and Steel Company on a rod mill. It may safely be said that these are the only installations that will ever be made as such sets have high cost, low power factor and low efficiency, besides being inflexible.

4. Changeable pole induction motors providing multi-speed control were used quite extensively before the development of adjustable speed sets but their use will probably be limited to those applications where two definite speeds meet all the rolling requirements, a condition which seems to have almost entirely disappeared.

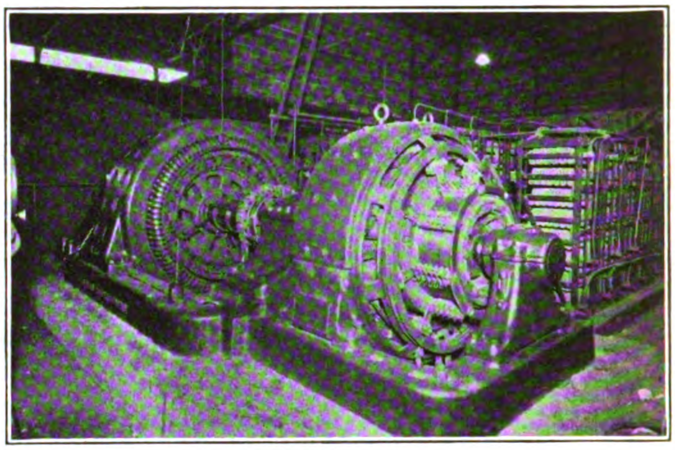

Fig. 3—Type I 12-1,400/950 hp.-600/405 rpm. for M 2,200 V. induction motor with direct connected auxiliary speed regulating motors. Type mpc.-8-0/450 hp.-600/405 rpm.-470 V. driving 21 in. structural mill at the Union Rolling Mills, Cleveland.

5-6. The development of adjustable-speed sets for wound rotor induction motors fulfilled the existing demand, for adjustable speed drives in a very satisfactory way. Fig. 3 shows the installation of a Kraemer set and Fig. 4 the installation of two Scherbius equipments.

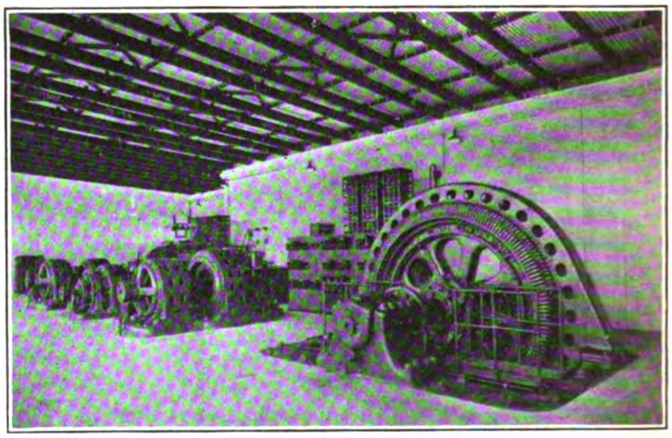

Fig. 4—Motor room, Acme Steel Good Co. 10 in. hoop mill showing in foreground finishing mill motor Type Mt.36 pole-1,800/1,500/1,200 hp. 240/200/160 rpm.-2,300 volt.

These equipments may be designed to meet any variation of load with speed; *i.e.*, constant torque, constant horse-power or any variation between these two; the speed may be varied over a wide range and having once been set, remains fairly constant independent of load; where a flywheel is used, means may be applied to utilize

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the flywheel energy effectively; the efficiency and power factor are high.

Demand for Individual Drives.

There seems, however, to be a growing demand for individual drive for the stands of continuous mills where the speed control requirements are most exacting. It is probable that in such cases, as in the case of the Trumbull Steel 14 in. hot strip mill, the installation of direct current motors may best meet the requirements even with the handicap of higher first cost and lower efficiency than alternating current drives.

The following tabulation shows in percentage the approximate ratio of total horse-power of various types of adjustable-speed motors to the total horse-power of all rolling mill motors, 300 hp. and above, built in this country up to the end of the year 1922.

1. D. C. motors with field control	5.87%
2. D. C. motors with Ward-Leonard control	
Reversing mills	16.4 %
Structural mills	1.2 %
3. Concatenated sets	.37%
4. Multi-speed induction motors	2.55%
5. Induction motors with Kraemer sets	4.41%
6. Induction motors with Scherbius sets	8.1 %
	38.90

Improving the Surface of Steel by Cold Rolling

Demand for Cold Rolled Steels Increasing Rapidly—The Automobile Has Been a Tremendous Factor—Description of the Process.

By J. H. McELHINNEY[*]

COLD rolled strip steel and flat wire are terms used interchangeably by many people, the finished product beng practically the same. However, the literal flattening of wire limits that product to comparatively narrow widths while cold rolled strip steel, first hot rolled from slabs and called hot rolled strip, may be secured in widths up to 22 in., the growing tendency being towards even wider material.

A few years ago the manufacture of cold rolled strip steel was confined to a few small specialty mills but today several complete steel plants have large strip departments turning out heavy tonnages. Present production of cold rolled strip steel is probably at a rate in excess of 1,000,000 tons annually with still more plants being attracted to the field. In fact, the increasing number of uses to which cold rolled strip steel has been adapted is one of the remarkable developments of the steel business during the last 10 years. This is due, among other causes, to the substitution of steel for the more expensive metals in the making of many drawn or formed parts, and this multiplied by the substitution in many cases of such formed parts for light castings and forgings.

The phenomenal growth of the automotive industry has "made" the cold rolled strip steel business, orders from that source occasionally being for a thousand tons or more of one size. Perhaps the biggest single factor in this rapid development is the comparatively recent adoption by many motor car builders of cold rolled strip steel for fender material.

Varying Characteristics.

The fact that cold rolled strip steel has not long been an important classification of steel products probably explains why the material is not well standardized. Buyers may require either a very bright finish, or merely a very smooth surface, or a strip exceptionally accurate in thickness or steel that will stand a deep draw and not care particularly concerning the other features. Obviously then most requirements must be studied individually and a working acquaintance grow up between the maker and the user. For some uses the color may be black as a sheet, while for others a finish that will show no spots through thin nickel plating may be required; for some uses the occasional occurance of pits or slivers may not be objectionable while in other cases an enamel may be applied that will magnify the slightest surface imperfection; for some uses cold rolled steel may vary four or five thousandths inches plus or minus from nominal thickness while other uses may require steel of equal width to be not more than one thousandth from nominal gauge; for some uses the harder and stiffer the strip the better; for other purposes a spring temper may be required while for still others the steel can hardly be made soft enough. For some uses a rough edge within a quarter inch of nominal width is acceptable while the other extreme requires a perfectly smooth round or square edge within five or ten thousandths of stated width.

Closer Specifications Demanded.

The general tendency seems to be toward more rigid requirements. large buyers often issuing their own specifications covering analysis, bend test or some ductility index, tensile strength, finish, character of edge and acceptable tolerances on all dimensions.

As with sheets, the base price of cold rolled strip steel is changed to suit market conditions. The base size is from 1½ inches to 6 inches wide by one-tenth inch or thicker, in coils and in hard temper. Standard extras are added to cover cost of making wider or thinner steel, to cut to length, to anneal, to prepare special edges, for small quantities, for higher than twenty point carbon and for boxing. Practically all cold rolled steel is sold f.o.b. Pittsburgh.

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[*] Assistant General Manager, Columbia Steel Company, Elyria, Ohio.

Raw Material.

While a considerable tonnage of narrow cold rolled strip steel is made by flattening wire, the larger percentage is made by cold rolling hot rolled strip steel. The latter is usually furnished in coiled form but may be in cut lengths if the thickness makes the coil too stiff for convenient working. Most cold rolled steel is made from soft basic open hearth steel but for special cases other analyses and steels are used.

Flatness in the hot rolled is a very important characteristic and soundness, both internal and surface absolutely essential in most cases. Steel used for drawn parts must obviously be free from pipe and as surface is all important to many users, such troubles as rolled-in furnace cinder, folded over "ragging" marks or broken through ingot bubbles must be avoided in so far as possible.

Manufacture.

To turn to the conversion of steel from hot rolled strip to cold rolled strip:

1. Pickling.

The first step in the manufacture is pickling, in principle the same as pickling in other lines.

Where fairly large tonnages of coils near a size are worked a continuous system, as used in wire industry, can be used to advantage but the wider and heavier sizes are usually pickled in coil form.

Coils as finished at the hot mill are so tightly wound that the pickling solution cannot circulate freely between adjacent wraps, so it is necessary to recoil (or to "open") loosely. Incidentally, this recoiling breaks off a large percentage of scale. The loosely wrapped coils are laid on edge on racks and handled into and from tubs by over-head cranes. Economical production has dictated larger and larger coils (1000 lbs. per coil being exceeded at some plants) until pickle tubs five or six feet across are usual. Most careful attention in arranging steel on racks is necessary to avoid "pickle spots" (black spots on the pickled steel) which betray where adjacent wraps have been in contact while pickling. The pickled strips are, at many plants, soaped to prevent rusting between times of pickling and cold rolling.

2. Piling.

Cut length strip is piled on racks, on edge, as in pickling sheets.

3. Cold Rolling.

The cold rolling, itself, of strip steel presents no unusual features. One end of the coil is entered in the rolls and as it emerges is caught in a power driven reel and coiled. Entering guides to hold the strip in line are used and include some form of wiper to clean the strip and a device to retard, or hold flat, thin steel. The reel is designed not only to coil the steel but to pull slightly; this also being of assistance in rolling thin steel flat.

Details of Milling Operation.

Rolls used are made either of chilled iron or hardened steel, the selection depending on work to be done. In any case the rolls must be ground accurately and polished as well as possible.

The reel is not the least important part of a cold rolling mill. Features embodied in a good reel are ease of catching steel as it comes through the mill, quick taking up of slack, strong steady pull on steel, quick stopping when piece is through the mill and sufficient collapse of drum that coil may be removed easily. The last point named often determines the capacity of a mill.

Reductions possible by cold rolling are less than in hot rolling but may reach more than twenty per cent of entering thickness if steel is very soft. As the steel hardens due to repeated passes the amount of reduction possible with same expenditure of power becomes less until at about 40 to 50 per cent of original thickness it is not economical to attempt further reductions without first annealing.

Tandem Mills Predominate.

Lay-out of mills varies widely in different plants but the tendency is toward tandem arrangement; that is, three or four or five mills set in line and 10 to 20 feet apart. The steel is passed through the set and not coiled until it leaves the last mill, thus saving considerable labor as compared to rolling entirely on single mills. To compensate for elongation, each mill of a tandem is equipped with a variable speed motor.

As it is difficult for a roller to work to same accuracy on a tandem set as on single mills, one or two single or finishing mills are usually installed to complete a unit.

In addition to the rolling mills cold rolled strip plants are equipped with finishing machinery such as rotary slitters, levelers, straighteners, shears, edge rolling mills, edge filing machines, cleaning machines, polishing machines, etc.

Annealing.

Cold rolled strip steel is practically always box annealed although continuous annealing systems have been developed at one or two plants.

Carburizing.

Perfectly annealed cold rolled steel is not only soft but bright. To assure the latter good, tight boxes must be used and the sand sealing must be done very carefully. Annealing boxes are drilled to allow the insertion of a small pipe through which a non-oxidizing gas, natural gas if obtainable, is fed from the time the retort is withdrawn from furnace until the steel is cool. Where natural gas, or good illuminating gas is not obtainable, a clean gas for cooling must be made.

Round, welded steel covers, large enough to hold one stack of coils, are just coming into favor, but rectangular, cast steel retorts 10 or 12 feet long, same as in sheet annealing, will continue to be used for that large percentage of strip that must be annealed in cut lengths.

Material Handling.

Furnaces, charging machines, if any, handling arrangements, heat control, etc., as in sheet annealing are crude or highly scientific, depending on the plant. In either case good annealing may be done but at higher labor cost in one plant than the other.

Fully annealed cold rolled steel is known as dead soft temper while strip rolled more or less after annealing is known as quarter hard (steel that will just stand a right angle bend along the grain), half hard (steel that will just stand right angle bend across the grain), three-quarter and full hard (steels that will stand very little bending or forming without cracking and intended for flat work only).

Cold rolled strip steel is shipped in cut lengths or coils and may be loose, bundled, burlapped or boxed, to suit the customer. In any case it is carefully oiled to prevent rusting and preserve the finish.

World Economic Situation for 1923

Chaos Seems to Be Giving Way to Constructive Programs—The Coming Year Has a Most Optimistic Aspect.

By Secretary of Commerce **HERBERT HOOVER**

THE following summary of the World's economic situation and prospects is based upon the special investigation of the department's representatives in each foreign country.

In the large view the world has made distinct economic progress during the past year and the conditions are very favorable to continued progress during 1923. There are in exception three or four states in Europe which give continued anxiety, but these exceptions should not obscure the profound forces of progress elsewhere over the whole world. In the main even in these areas of uncertainty the difficulties are to a large degree fiscal and political rather than commercial and industial.

During the year the world generally has gained in social stability; Bolshevism has greatly diminished and even in Russia has been replaced by a mixture of socialism and individualism; at least active war has ceased for the first time since 1914; famine and distress have diminished to much less numbers this winter than at any time since the great war began; production has increased greatly during the past year; unemployment is less in world totals than at any time since the armistice; international commerce is increasing; the world is now pretty generally purchasing its commodities by the normal exchange of services and goods, a fact which in itself marks an enormous step in recovery from the strained movements of credit and gold which followed the war.

The world has gained in social stability; production has increased greatly during the past year and international commerce is increasing.

The healing force of business and commerce has gained substantial ascendency over destructive political and social forces.

The world has shaken itself free from the great after-war slump and it may truthfully be said that the odds are favorable for 1923.

In our country unemployment has ceased to be a problem and we are indeed upon an economic level of comparatively great comfort in every direction except for the lag of recovery in some branches of agriculture. Even in this field there has been a distinct improvement in prices in the past 12 months and its troubles are mostly due to over production in some lines. Our manufacturing industries are engaged well up to the available labor; industrial production has enormously increased over last year; real wages and savings are at a high level. Our transportation and housing show great gains in construction, though we are yet behind in these equipments. Both our exports and imports are again increasing after the great depression and are today far above pre-war levels.

Outside of Europe the whole world has shaken itself free from the great after-war slump. The economic wounds of Asia, Africa, Latin America, and Australia from the war were more the sympathetic reaction from slump in the combatant states than direct injury. Their production and commerce has recovered to levels above pre-war. The enforced isolation of many areas in Latin America and Asia during the war has strengthened their economic fibre by increased variety of production and has contributed vitally to their effective recovery.

In Europe, England together with the old neutral nations is making steady progress in production and diminishing unemployment. Their trade and commerce are improving; their governmental finances are growing stronger; their currencies that are not already on a gold basis are steadily approaching par; and their exchanges are more stable. The combatant states on the Continent are slower in recovery. Even these nations, including Russia, have shown progress all along the line in commercial, industrial and agricultural fields, although the harvests suffered in some spots. Some of these nations, such as Italy, Belgium, the Baltic States, Poland, Czechoslovakia and Hungary show increasing political and social stability and improvement in their governmental finances. In Germany and some minor states in Southeastern Europe governmental finance and political difficulties threaten to overwhelm the commercial and industrial recuperation already made.

The continued maintenance of armies on a greater than pre-war basis in the old allied states maintains political uncertainty, lowers productivity, and retards the balancing of budgets with consequent cessation of direct or indirect inflation. Disarmament and the constructive settlement of German reparations and the economic relations of states in Southeastern Europe are the outstanding problems of Europe, and their adjustment to some degree will affect the progress of the rest of the world. The more general realization during the past year of the growing menace of these situations and the fundamentals that underlie their solution is in itself some step toward progress. Their solution would mark the end of the most acutely destructive forces in the economic life of the world which still survive the war.

Economic forecast can not amount to more than a review of the tendencies and a hazard in the future. The odds are favorable for 1923; the world begins the year with greater economic strength than a year ago; production and trade are upon a larger and more substantial basis, with the single exception of the sore spot in Central Europe. The healing force of business and commerce has gained substantial ascendancy over destructive political and social forces. There is ample reason why there should be continued progress during the next 12 months.

Heat Treatment of Steel Castings

Steel Castings, Their Characteristics in the Raw and Thermally Treated Condition—Consideration of the Correct Treatment with Relation to Size and Composition of Casting.

By H. C. IHSEN*

BECAUSE of their comparatively low cost and relative ease of forming into intricate shapes, steel castings are very considerably used in engineering structures. Many parts as designed would be very expensive to fabricate or machine and casting is the only practical method of manufacture. However when in the raw condition, cast steel has the great disadvantage of lacking the strength and ductility of the same grade of steel hot rolled or forged. To improve the physical properties to a point nearly comparable to those of forged or rolled steel, various thermal treatments can be given, such as annealing, normalizing, or quenching and drawing, and when so treated, if properly made in the foundry, steel castings supply a reliable material at a comparatively low cost.

Raw Steel Castings.

After molten steel is poured into a mold, slow and undisturbed cooling takes place, starting from an exceedingly high temperature, the rate of cooling depending on the size and weight of the casting and the material and condition of the mold. During this slow and undisturbed cooling crystalline grain growth is going on, whereas during rolling or forging grain growth is hindered or corrected by the kneading action of the rolls, hammer or press. Grain growth continues until the lower thermal critical range is reached and since steel castings usually cool very slowly the result is a very coarse grained material.

The mechanism of cooling of hypo-eutectoid steels—that is those under approximately 0.90 per cent carbon—will be considered first. Upon solidification the liquid solution of carbon or iron carbide in iron is converted into a solid solution of carbon or iron carbide in gamma iron, namely austenite, which is made up of polyhedral crystalline grains. During the slow cooling of the steel casting after solidification, these grains are constantly growing in size by the merging of adjacent crystals. When the upper thermal critical range is reached, free ferrite starts to precipitate and continues to do so until the lower thermal critical range is reached, when the eutectoid, pearlite, is precipitated. Pearlite is that mixture of ferrite and cementite, iron carbide, having the lowest melting point, and when examined microscopically it is found to consist of alternate plates or lamellae of the two constituents. Examined microscopically after cooling, therefore, hypo-eutectoid steels show a mixture of pearlite and ferrite, the proportion of ferrite being larger the lower the percentage of carbon in the steel.

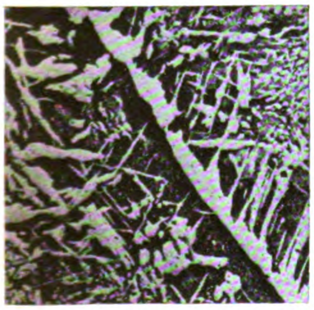

Fig. 1—Raw Casting. Mag. 50 X.

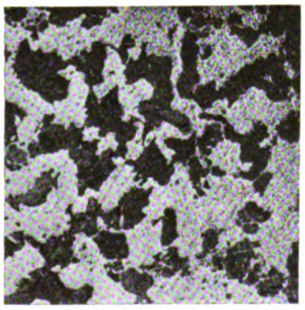

Fig. 2—Annealed casting. Mag. 50 X.

Large steel casting. The grains in the raw casting examined are about ⅛-inch or more diameter.

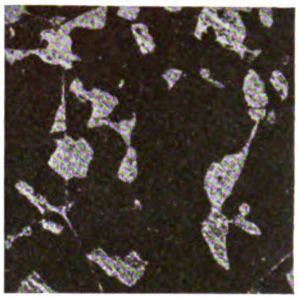

Fig. 3—Raw casting. Mag. 50 X.

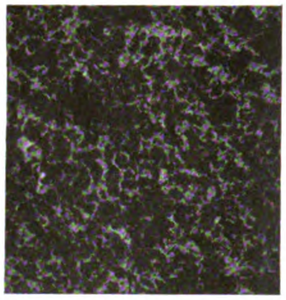

Fig. 4—Annealed Casting. Mag. 50 X.

Blooming mill roll "A"

The mechanism of freezing of hyper-eutectoid and eutectoid steel is similar to the above except that in the case of the hyper-eutectoid steels free cementite is precipitated after the upper thermal critical point is passed, while eutectoid steels have bue one thermal critical point and no excess constituent is precipitated, the structure consisting entirely of the eutectoid—that is polyhedral grains of pearlite.

If an etched section of raw cast steel is examined with the microscope, the excess constituent in either the hypo or hyper-eutectoid steels, ferrite or cementite, is found either at the boundaries of the austentitic grains or in needle shaped particles at the crystalline cleavage planes of the alloy. The tendency of the excess constitutent to form either at the grain boundaries or in the cleavage planes depends upon the temperature from which undisturbed cooling takes place and the rate of cooling. Slow and undisturbed cooling from an exceedingly high temperature causes the excess constitutent, either ferrite or cementite, to be precipitated upon cooling at the cleavage planes, while it is precipitated nearly entirely along the polyhedral grain boundaries in steel heated to a temperature but little above the upper thermal critical range, or worked until it has about reached this temperature range.

Since steel castings usually cool very slowly from an exceedingly high temperature, a large part of the ferrite or cementite is found in the cleavage planes. The size of the casting, which generally controls the rate of cooling, and also the temperature of the molten steel, will influence the relative amount of the constituents thrown into the cleavage planes or into the grain boundaries. The size of the austenitic grains also will be governed by the same factors. Therefore, large size castings and high casting temperatures cause exceedingly large grain size with a lot of the excess constituent in the cleavage planes, while smaller grain size with less cleavage structure will result from lower casting temperature and smaller castings. Cast eutectoid steels, consisting entirely of pearlite, contain no constituent in the cleavage planes, large austenitic grain boundaries only being found.

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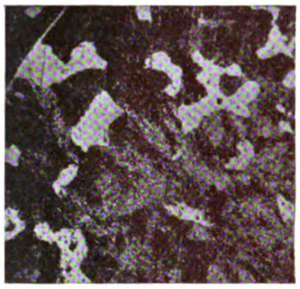

Fig. 5—Raw Casting. Mag. 50 X.

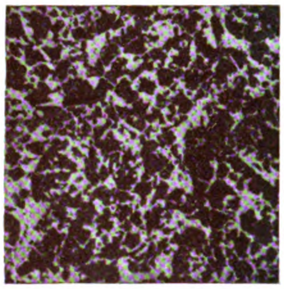

Fig. 6—Annealed casting. Mag. 50 X.

Blooming mill roll "B."

Figs. 1, 3, 5, and 7 illustrate the large grain size and cleavage or "Widmanstaetten" structure of raw steel castings. All micrographs are of the etched section magnified 50 times. However, the grain size of a raw casting is usually so large that a micrograph cannot properly depict it. Usually the polyhedral grains will vary in size when viewed with the naked eye after polishing and etching, from 1/16 in. diameter up to one in. or more. Sometimes the "Widmanstaetten" or cleavage structure can be seen with the naked eye.

Fig. 1 shows a ferrite grain boundary diagonally crossing the field with the dendritic formation at either side. In Figs. 3 and 5 the ferrite grain boundary of a single grain is partly shown. Fig. 7 shows the dendritic formation, no grain boundaries being visible.

The very large grain size and cleavage structure found in raw cast steel causes brittleness and lack of ductility. Incipient fractures are very readily started either in the large grain boundaries or in the straight line constituent in the cleavage planes, and once started, travel very rapidly because little resistance is offered to the path of rupture.

Steel subjected to an excessively high temperature is overheated and it is distinguished from burned steel in that it can be at least largely restored to its original properties by heat treatment while in burned steel intergranular oxidation has taken place and the material is irretrievably ruined. Micrographs 8 and 9 illustrate the structure of hot rolled steel that was overheated and as can be seen the same general cleavage structure is found as in the raw cast steel. Both in the raw castings and in the overheated steel cooling took place starting from an excessively high temperature and the effect of this high temperature is the same in each case, namely, the forcing of the excess constituent into the cleavage planes accompanied by considerable grain growth.

As is well known, overheated steel has poor physical properties; the similarity in microstructure implies the same for raw cast steel. Consequently, the use of raw steel castings when subjected to fairly heavy stresses is not good practice because failure is quite liable to occur.

Thermal Treatment of Steel Castings.

Various thermal treatments—annealing, normalizing, or quenching and drawing—can be applied to raw steel castings to improve their properties. The objective in all these treatments is a refinement of the large grain size and cleavage structure characteristic of raw cast steel. These various treatments will be considered below.

Annealing of Steel Castings.

In annealing the raw castings are placed in a furnace and heated to a temperature considerably above the upper thermal critical range. After the entire charge has reached the proper temperature and has been soaked at this temperature for a sufficient time, depending upon the size and weight of the charge, the castings are slowly cooled in the furnace, or in lime, mica, or some other medium that permits slow cooling.

When heated to a temperature above the upper thermal critical range, the structural components form a solid solution, austenite, with the consequent elimination of the very coarse grain size and cleavage or "Widmanstaetten" structure of the raw casting. When cooling takes place, it is from the annealing temperature instead of the excessively high temperature from which the raw casting cooled, so that while some grain growth takes place, it is not comparable to that occurring in the raw cast steel. Also, in cooling from the annealing temperature, most of the excess constituent is precipitated at the grain boundaries.

Annealing, therefore, breaks up the exceedingly coarse grain size and cleavage structure of the raw casting, substituting a much smaller grain size with most of the excess constituent in the grain boundaries with consequently superior properties.

An idea of the change resulting in the microstructure due to annealing is given in Figs. 1 to 6. Figs. 1 and 2 illustrate a large casting before and after annealing. Cutting diagonally across the field in Fig. 1 can be seen one of the ferrite grain boundaries. It is beyond the scope of the micrograph to show the size of this grain because when the etched sample was viewed with the naked eye the individual grains were about 1/8 in. or more in diameter. The crystallites, or needles, of cleavage ferrite are also very prominently shown. Fig. 2, which is the same material as in Fig. 1, except after annealing, shows a fair grain size without any of the needles so noticeable in the other micrograph.

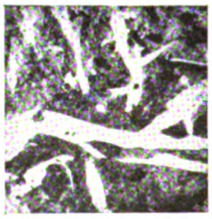

Fig. 7—Raw cast blooming mill roll. Mag. 50 X. Carbon .43, manganese .65, phosphorus .040, sulphur .035, silicon .30.

Figs. 3 and 4, 5 and 6, show the structure and grain

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size of coupons cast on large blooming mill rolls before and after annealing. Part of the ferrite grain boundary of one grain only is distinguishable in the micrographs of the raw castings, while the micrographs of the castings after annealing show a very much finer grain structure with all the ferrite in the grain boundaries and none in the cleavage planes.

The physical test values of these rolls in the raw and annealed condition and the chemical composition are given below:

	Roll A	Roll B
Carbon	.49%	.48%
Manganese	.76	.63
Phosphorus	.045	.048
Sulphur	.040	.036
Silicon	.31	.24

	Roll A		Roll B	
	Raw	Annealed	Raw	Annealed
Yield point (lb./sq. in.)	41,600	44,980	40,240	43,900
Ten. strength (lb./sq. in.)	81,000	91,860	79,540	88,520
Per cent elongation (2 in.)	9.5	15.0	11.0	17.5
Per cent reduction area	9.3	18.1	9.6	22.0
Bend test (degree bend)	75°	125°	85°	135°

These figures show a great improvement effected in the properties of the steel by annealing.

Annealing, like all other processes, can either be carried on in a slipshod and haphazard manner or in a careful and scientifically directed manner. When carelessly performed, the results will be erratic and unreliable and the desired improvement in the properties of the castings not attained. The process requires intelligent direction and control and the actual operation should be in the hands of a fairly skilled, reliable man. Proper pyrometer equipment is necessary and should be, if possible of the recording type.

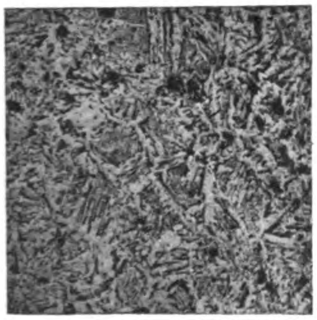

Fig. 8—Mag. 50 X. .23 per cent carbon steel. Overheated.

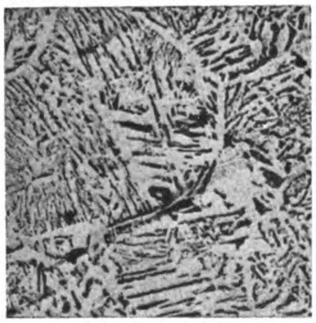

Fig. 9—Mag. 50 X. .24 per cent carbon steel. Overheated.

A test of some kind is essential to determine whether or not the expected results are realized. Test coupons should be cast on large castings and left on until treatment is completed, while in an annealing charge of small castings test bars can be treated with the charge. The standard tensile test often gives some measure of the quality of the annealing, but cannot be depended upon to indicate reliably whether the annealing is properly done or not, largely because of the porosity often found in cast steel. It has been noted by examination of the results of a large number of tests on raw and annealed castings on which both tensile and microscopic tests were made that especially in the lower carbon range the material whose microstructure shows considerable cleavage structure will often have as good tensile properties as material whose microstructure shows it to be perfectly refined. The bend test is more reliable in its results than the tensile test and serves as a good guide to the quality of the treatment.

Examination of an etched section of the coupon under the microscope will show more accurately the results of the annealing than any other test. The usual examination of the fracture also is very reliable for to the practiced eye the appearance of the fracture and the structure seen with the microscope are very closely related.

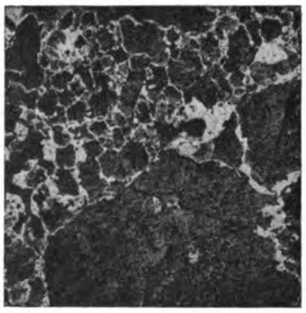

Fig. 10—Cast steel blooming mill pinion. Given single annealing treatment. Mag. 50 X.

Figs. 11 and 12 were taken of coupons cast on and annealed with a large blooming mill pinion. Both tests were at the back of the furnace, test "A" at the top and test "B" at the bottom of the casting. As may be seen on examination of the micrographs, neither coupon shows proper annealing, the structure in test "B" in particular being little different from what would be found in a raw casting. Here the examination of the etched section with the microscope caught this instance of poor annealing and the material was retreated, whereas a tensile test only may probably have it as satisfactory.

Double Annealing.

In annealing a raw casting it is necessary to heat to a temperature considerably above the upper thermal critical range in order to break up the casting structure. This consequently results in a considerable length of time in cooling before the critical range is reached and during this time grain growth is taking place. As a result, it is not possible to get as fine grained a structure from annealing as is often desired, especially if the castings are of a large size so that very slow cooling takes place.

To remedy this condition, a double annealing is resorted to. The casting is first annealed at a temperature considerably above the upper thermal critical range and allowed to cool slowly. This breaks up the extremely coarse grain size and cleavage structure of the raw casting but the grain size is still rather large. A second annealing treatment is then given at a temperature just above the upper thermal critical range, resulting in a material with a fairly fine grain size.

Fig. 10 shows the etched section of a large blooming mill pinion given a single annealing treatment. The cleavage structure is entirely broken up but because of the high temperature required the grain size is rather large. Here is an instance where a double annealing treatment would have been beneficial.

Figs. 13 and 14 illustrate the results that can be attained on large castings by the double treatment. The micrographs were taken of two test coupons attached to a large roll weighing several thousand pounds and show as good grain size and structure as can be expected for a casting of this size.

Normalizing of Castings.

Crystalline grain growth in a steel casting cooling from the annealing temperature depends largely on a time factor, the length of time cooling before passing the lower thermal critical temperature. If by some means this time period of cooling can be shortened, a better grain structure will be attained with a consequent enhancement of the properties of the casting. Normalizing, that is, air cooling of the castings from the refining temperatures, is employed for this purpose and, if possible of application, will give better results than the furnace cooling of the annealing process. Often, however, this process is not desirable because the heat of the cooling charge interferes with men working near the furnace, or the castings may be of high carbon steel so that machinability is poor. When applicable, however, very good results are obtained, especially with small castings.

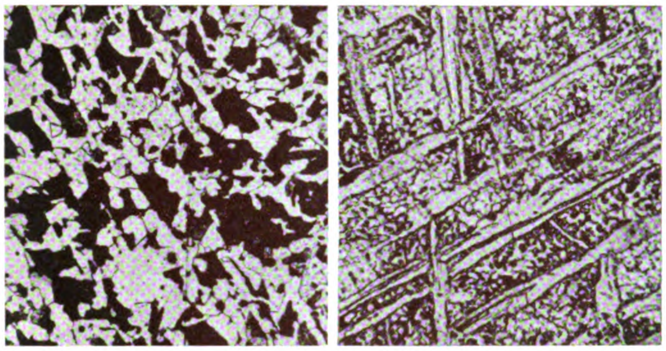

Fig. 11—Test A. Mag. 100 X. Fig. 12—Test B. Mag. 100 X.

Coupons annealed with blooming mill pinion.

Quenching and Drawing of Steel Castings.

A slightly more complicated and expensive thermal treatment for steel castings consists of quenching and drawing, but the results attained are very much superior to those of either annealing or normalizing, especially in small or medium size castings. The raw steel castings should first be given a preliminary annealing or normalizing treatment, then reheated to a temperature just above the upper thermal critical range and quenched from this temperature into cold water or oil. The quenching to be followed by a drawing or tempering treatment to relieve cooling strains and to reduce the extreme hardness resulting from quenching. The rapid cooling due to quenching prevents grain growth and consequently the microstructure should show a fine grain size.

This process is more applicable to small or medium size castings than to large castings because the rate of cooling would not be as rapid in quenching large castings and the mechanical difficulties in handling would be greater.

When steel castings are subjected to fairly heavy stresses in service, the increased cost of treatment over annealing or normalizing is much more than offset by the superior physical properties attained. Often when trouble with failure of steel castings is encountered, a solution can be found in a quenching and drawing heat treatment.

Heat Treatment of Fans for Motors.

Cast steel fans used on street railway motors subjected to severe operating conditions furnish an example of castings requiring high physical properties in order to resist heavy stresses. Originally, the fan castings were annealed at the foundry, which gave properties considerably better than those of the raw castings. To further improve the properties of the castings and thereby meet the severe operating conditions, a heat treatment consisting of quenching and drawing was resorted to.

The castings were first given the usual annealing treatment at the foundry. They were then reheated to a temperature of 875 to 900 deg. C. and quenched at this temperature in oil. After quenching they were drawn in a furnace at 625 deg. C.

The difference in microstructure of the motor fan castings in the raw, annealed, and quenched and drawn condition is shown in Figs. 15, 16 and 17, micrographs of the etched section magnified 50 times. Fig. 15 shows the cleavage structure typical of raw cast steel and this fan would be expected to show poor physical properties.

The microstructure after annealing is shown in Fig. 16. Close examination will show that while the grain size is fairly small, the structure has not been well refined, for the micro-constituents—the ferrite and pearlite—are arranged in a pine tree formation. This can be more readily seen if the picture is examined at a considerable distance from the eye. While the properties have been considerably improved over those of the raw casting, they are still not as high as desired, for the arrangement of the micro-constituents in pine tree formation provides planes of weakness that may result in failure of the casting.

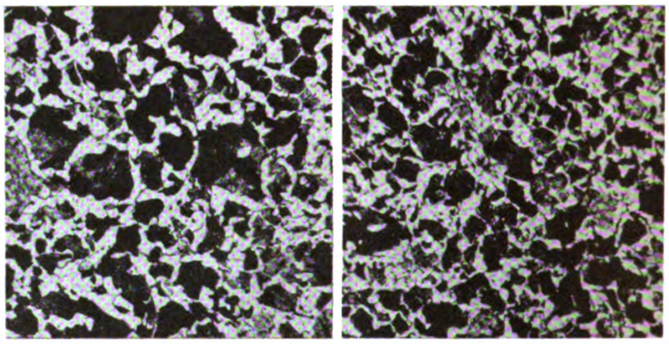

Fig. 13—Test A. Mag 100 X. Fig. 14—Test B. **Mag.** 100 X.

Coupons annealed with blooming mill roll. Carbon .54, manganese .64, phosphorus .030, sulphur .035, silicon .33.

The structure obtained in the casting after quenching and drawing is shown in Fig. 17, this casting being but slightly higher in carbon than the one illustrated by Fig. 16. The small grain size and uniform granular structure obtained by the heat treatment show a very desirable condition and predicate greatly increased strength over the casting in the annealed condition.

To obtain a concrete idea of the improvement effected in the properties of the steel fan castings by the heat treatment, foundry annealed and heat treated (quenched and drawn) fan castings were bent and broken in a tensile testing machine. The castings were placed upright in the machine and compressed and bent until failure took place. The heat treated fans required about twice the load to bend and fracture that the annealed fans did, and also bent to a much greater degree before fracture took place. The fracture of the heat treated fans in all cases were very much finer than the annealed fans.

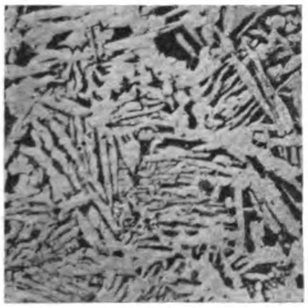

Fig. 15—Fan casting. Raw Cast steel. Mag. 50 X.

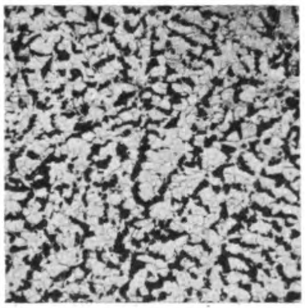

Fig. 16—Fan casting, Annealed at foundry. Mag. 50 X. Shows pine tree structure.

The heat treatment of these fan castings, therefore, assured uniform and high physical properties at but a slight increase in cost. Also, the use of any castings in the raw condition due to having accidentally escaped the annealing treatment in the foundry was obviated.

Summary.

In conclusion, the undesirability of using steel castings in the raw condition should be emphasized. Their physical properties are poor and they possess little shock resisting ability due to the large grain size and poor structure inherent in raw castings. However, the properties of the raw castings can be greatly improved by heat treatment and after treatment steel castings furnish a reliable material if properly made in the foundry.

Fig. 17—Fan casting. Mag. 50 X. Heat treated, quenched in oil at 875-900° C, drawn at 25° C.

The various thermal treatments in the order of the successive improvement effected in the properties of the steel castings are as follows:

1. **Single Annealing Treatment.**

Heating to a temperature considerably above the upper thermal critical range and cooling slowly in furnace.

2. **Normalizing Treatment.**

Heating to a temperature considerably above the upper thermal critical range and cooling in air.

3. **Double Annealing or Normalizing Treatment.**

(a) Heating to a temperature considerably above the upper thermal critical range and cooling slowly in furnace or rapidly in air.

(b) Reheating to a temperature just above the upper thermal critical range and cooling slowly in furnace or rapidly in air.

4. **Quenching and Drawing Treatment.**

(a) Annealing or normalizing.

(b) Reheating to a temperature just above the upper thermal critical range and quenching in cold water or oil.

(c) Drawing or tempering.

The treatment that will be most desirable to give to a casting will depend upon the service to which it is subjected and also will be governed to some extent by the size and weight of the casting.

The Universal Portland Cement Company announces a substantial reduction December 28 in the prices of Universal cement. The reduction is 15 cents per barrel at its Chicago plant, and 10 cents per barrel at its Pittsburgh and Duluth plants.

The Jersey City Welding Shop of the Metal & Thermit Corporation in addition to its present excellent facilities has been equipped for making welds on lighter sections by means of the oxy-acetylene and electric processes. This service will be of particular value in cases where large production work is desired. They are now in a position to undertake prompt welding repairs or quantity manufacturing of all kinds. Work can be called for and delivered by truck. This policy of equipping welding shops with the additional welding facilities, as described above will later be extended to the other welding plants of this company.

FOREIGN COMPETITORS UNDERSELLING AMERICANS IN CALCUTTA AND KARACHI

Consumption of iron and steel in India has not nearly regained its pre-war volume and the potential market is large, but although American products have an excellent name in several of the provinces, comparative prices with other countries have placed them at a disadvantage, according to advices received by the Iron and Steel Division of the Department of Commerce. Quality counts very little in the Calcutta market; importers customarily buy the cheapest goods, being interested only in the price. Foreign competition fortified by the high exchange value of the dollar has virtually eliminated American iron and steel from the markets of the Karachi district.

The American steel products imported into India in August were: Four tons of beams, girders, etc.; 108 tons of bolts and nuts, five tons of hoops and strips, five tons of nails, other than wire; 886 tons of cast pipes and fittings, 363 tons of galvanized sheets and plates, 1,925 tons of tinplate, 1,789 tons of sheets and plates not tinned or galvanized, 680 tons of wrought tubes, pipes, and fittings, 134 tons of wire nails, nine tons of wire rope, 1,492 tons of bars and channels. The bulk of the steel products imported came from the United Kingdom.

Fire-clay Refractories for the Steel Industry

$25,000,000 Spent Annually for These Materials—The Value of Scientific Methods and the Relation of Impurities to Melting Points—High Heat-Resisting Clays Are Very Scarce.

By CHAS. L. T. EDWARDS

THE writer, previous to becoming affiliated with a large manufacturer of fireclay products in the Middle West held supervisory positions in three of the major departments of the steel industry and has since been able to study the refractories problem from the producer's viewpoint as well as from that of the furnace operator.

A few gentle reminders to the furnace man and a little light upon the problems of the manufacture may open the way to better co-operation between maker and consumer. Needless to say, this is a live subject.

The following may be considered the most important uses of fireclay materials in the steel industry; blast furnace and blast furnace stove linings complete, openhearth checkers, checker chambers and flue linings complete. Rolling mill reheating furnaces and soaking pits complete. Forging furnaces, Bessemer converter linings, bottom blocks and tuyeres, cupola linings and types, metal mixer linings and drying ovens are all important. Electric furnace, crucible furnace, malleable iron, busheling furnace and gas producer, and gas bench linings complete, crucible and pot mixes; muffle furnaces, stoppers, sleeves, nozzles and runner brick; all manner of stoker and boiler, brick and tile; coke oven linings (allied industry); clays for all brick settings including those of silica, ball mixes and clays for high temperature cements are large users of refractories.

With the foregoing materials costing the industry upward of $25,000,000 per annum, considerable saving and increased earnings may justify careful thought concerning proper selection and use of these materials.

Specifications to Be Met.

In addition to increasing temperatures, the brickmaker strives to meet the following requirements:

1. If the firebricks are not sturdy enough to resist the punishment meted out through handling at the kilns, loading, storing and rehandling perhaps many times prior to installation, the market for that brick will soon grow dull. The importance of this qualification is exemplified in the efforts of the maker to ship properly by packing in straw and even by crating. Unfortunately these precautions cost money and the consumer must pay.

2. The importance of chemical resistance is best demonstrated in the glass industry for the reason that although the prevailing temperatures are not so high as those found in the steel industry, such elements as zinc, arsenic, the alkali metals, lead, etc., existing in large proportions are destructive at moderately high temperatures. In the ferrous industry higher heats aid in the destructive influences of the fluxes.

The clays are expected to withstand the chemical action of acid, basic and neutral materials in the form of gases, vapors, metals and slags. The most important are iron and its compounds with carbon, silicon, manganese, sulphur and oxygen, and innumerable compounds of aluminum, chromium, titanium, calcium, cyanides etc.

3. The firebrick must have a low coefficient of expansion. One can readily understand the disastrous results to be expected if a blast furnace stove, having an insulated shell were to be lined with firebrick which had a high expansion coefficient. The same general results would be obtained in boiler settings, checker chamber walls, crucible pots, furnace roofs, etc.

4. The fireclay brick must be infusible at a temperature above that contemplated under working conditions.

The ultimate requirements of the brick in a blast furnace stove are hardly realized. With the great mass of brick work above, the pressure at various points in the lower sections will range from a few pounds to several hundred of pounds per square inch. In addition to the normal pressure we have fluctuations due to vibration caused by the throb from the blowing engine. More important is the fluctuation due to temperature changes. In addition to the internal strain the pressure is increased during the rise in temperature, due to resistance offered by the shell, to expansion, particularly linear expansion. During the contraction the shell will partially support the brick work.

Exceptional Characteristics.

The foregoing requirements are only preliminary. The pressures must be withstood under temperature changes ranging from atmospheric to those of bright incandescence while constantly attacked by fume and suspended material in the gases.

The fact that the brick in the hearth of a blast-furnace will be there after a million or more tons of coke have been burned before it, by the admixture of superheated air, while at the same time the brick must act as a retainer for flowing metal and slags, resisting the abrasion from materials and defying the chemically active gases is surely marvelous.

What percentage of the openhearth first helpers (individual furnace operators) are educated to the importance of properly using their checkers? How often is a damper raised or lowered? Do they go down once in three months and examine their checkers? What a difference there will be in the life of the checkers when 75 per cent of the fuel is burned in the furnace The life of the checkers will be increased indefinitely. With the gas burning in the chambers, the brick at sweat heat, unburned and incandescent carbon with many slag forming materials carried over with the products of combustion—there can be but one result.

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The treatment given malleable furnace bung brick is little less than a scandal.

Improvement Noticeable.

Consistent improvement is being made in the manufacture of high alumina brick and while it has not yet reached the desired point in resistance to chemical action, it will stand temperatures over 3600 deg. F., and has greater strength and less change in volume than any other fireclay material. To date, the high alumina brick manufactured from the native clays appear to be more successful than those made from mixtures of other aluminious materials. These special brick are finding an expanding use in the electric furnace.

The recent discussion of blast furnace failure on account of zinc might well have been replaced with an argument concerning what maximum temperature, time and pressure should be used in drying a furnace lining previous to "blowing in." The tendency now, which is proper, is to lay the brick up with as little fireclay as possible, use no cement of any kind with the clay, make the joints right though if it does take a little longer and above everything else, finally, eliminate as much moisture as possible.

The physical condition of moist firebrick, when exposed to freezing weather, will deteriorate. Water when frozen in a bottle will usually break it. This principle applies to the hundreds of millions of microscopic voids which exist in a brick, the voids being the bottles.

Scientific Methods Now Employed.

While there are many complaints registered in the name of poor refractories which could be readily explained, improvement in refractory quality has gone steadily on. People who have built blast furnace linings in earlier days but since left the game have acquired the services of mining engineers and trained ceramists, have secured deposits of better clays, developed the art of clay blending and testing, of clay washing, grinding, mixing, moulding, air and waste heat drying, and burning. Proper use of the Seger Cone with scientific regulation of kiln temperatures and burning have alone added inestimately to the merits of the product.

Little is known of the importance of clay blending to obtain the desired results. As an illustration: Suppose a certain mix, after grinding, drying and burning gives a certain melting point. Now, before mixing the raw clay, let us take one of them and calcine it thoroughly. Should this clay previously have contained pyrities, it would no longer contain that compound as it would have been oxidized during the firing. After making up our mix, as previously, with the exception of the particular clay having been burnt, the melting point of our finished product will be changed. In the first case, the iron may have ceased to exist as pyrities but the sulphur would have been distributed throughout the brick mass. And should any element there have an affinity for it, it would have every opportunity of being satisfied. From the foregoing illustration one can readily see the importance of scientific study along the lines shown.

The fundamental requirement of a clay is, after being refractory, that it has bonding power, or a certain degree of plasticity. This plasticity comes from collodial matter and particles of microscopic fineness, individually coated with a film of water, and thoroughly distributed throughout the mass. During the process of washing to eliminate certain undesirable elements, the collodial matter is largely lost, but fortunately may be replaced through blending.

Experience has shown that fire brick of equal quality cannot be manufactured from mixes other than of clays; that is, although one may have the same identical chemical analysis as the other, it does not follow that the quality of the brick will be equal.

Impurities Result in Lower Melting Point.

Before discussing the methods through which improvement may be obtained in the manufacture and uses of fire brick there is a point which should always be borne in mind. Although well known, it has not been acknowledged fully enough, and will stand considerable repetition, viz.: Other things being equal, the more impurities there are in a substance, the lower will be its melting point. This rule can be demonstrated in many ways; for instance, from the time pig iron enters the open hearth furnace until it is tapped as low carbon steel its temperature continually rises. The temperature of the charge in a puddle furnace continually rises after the melt, until at near its maximum temperature it is drawn as a plastic mass—the purest form of commercial iron. Working the other way, if we add the metal tungsten with its extremely high melting point to low carbon steel in a certain proportion, the alloy will have a lower melting point than the original steel. Add a little impurity, lime, to a cupola charge and we obtain an easily fusible slag.

By treating fireclay brick with flue dust, or fume, we can soon knock in the well wall of a blast furnace stove. The brickwork along the clinker line of a boiler does not "go" so rapidly on account of the temperature; it is due to absorption by the brick, of impurities at that point, which lowers the melting point, creating a slagging action. This is particularly true when the boilers are operated at a high rating on forced draft, the internal pressure driving the heat, as well as the impurities through the brick.

Comparative Mixtures.

In approaching the subject of brick structure it may be well to show some comparative figures concerning the two compounds which form the basis of fireclay brick namely silica and alumina.

Seger cones have shown the following:

Mix	Softening Temperature
Pure Al_2O_3	3580° F
$1Al_2O_3$ plus $1/3\ SiO_2$	3540° F
$1Al_2O_3$ plus $1\ SiO_2$	3468° F
$1Al_2O_3$ plus $5\ SiO_2$	3182° F
$1Al_2O_3$ plus $10\ SiO_2$	3072° F

On increasing the ratio of silica, the temperature begins to rise until, when pure, it softens at about 3300° F.

By adding impurities to the Al_2O_5 plus SiO_2 we are further informed

$$1Al_2O_3 + 10SiO_2 + \frac{.086K_2O}{.2\ CaO} \qquad 2750° F$$

$$1Al_2O_3 + 10SiO_2 + \frac{.6\ K_2O}{.4\ CaO} \qquad 2246° F$$

The softening points continue lower as Fe_2O_3, and BO are added. However, we must not come to a hasty conclusion in judging the softening point of a fire brick from chemical analysis, for the reason that the mechanical mixture of silica and alumina would obviously not yield to the same temperature as the double oxide of silicon and aluminum. The same principle applies to the basic materials lime and magnesia. Neither magnesia nor lime would melt at as low a temperature as the compound of them, nor a mechanical mixture of the two.

Further, the mineralogical form of the material will influence the fusion point although the chemical analysis be the same, for example, 1 alumina plus 2 silica as schist softens at 3326 deg. F., whereas 1 alumina plus 2 silica as caolin softens at 3362 F. This is not a great difference in number of degrees but an increase of 10 deg. above 3300 is more important than an increase of 500 deg. above 2000 deg.

The Best Clays Mined at Great Depths.

While high grade clays may be found at the surface, it is not unusual to go thousands of feet underground for those of the same or a little better quality. If 10 deg. can be added to the melting point of brick work when a temperature of 3200 deg. F. is reached, those 10 deg. justify the search for better clays. Clays which resist 2900 deg. are widely distributed, and in unlimited qualities, but those which resist 3200 deg. are scarce; at 3300 deg. they become rare.

Clays alone may be found, but usually they require bonding and blending to obtain certain qualities before going to practical use.

Once having the clays the manufacturer has the following agents to work with to obtain the best there is in them: The ceramist will determine the mode of occurrence of the constituents which make up the clays. It is his duty to determine into what forms the various elements may be compounded, whether into a mechanical mix or chemical compound, keeping in mind the change which will take place through absorption when in actual service.

The Task of the Ceramist.

In his turn, the ceramist has in order of importance, the picking and selection of the clays, weathering, washing, pre-firing, grinding, screening, mixing (raw, burned or both), pugging, aging of the mixed clay, moulding (hand, steam-pressed, mud, dry and repressed). Drying (air and waste heat) and firing, are vital factors. This latter statement can be explained better after a brief outline of clay construction.

Geologists tell us that fireclays are principally of sedimentary origin and formed from the decomposition of feldspathic rocks. The limit of decomposition through the ages would therefore be the molecular condition. Further, the mode of occurrence usually finds them in the neighborhood of coal measures. This accounts for the evidence of organic material in the clay although it exists only as a trace. As sodium is found in practically everything occurring in nature, we would naturally expect to find it in clay, and with it potash. All clays contain small quantities of lime and iron oxide and usually, titania.

Experience has shown, particularly as regards large blocks of tile, that after the mix has been made up and before moulding, it should be piled and covered with wet burlap or its equal. The effect of this aging is to permit every particle of clay to take up its share of moisture. A hard "grog" may be soaked well on the outside through pugging but it takes time for the moisture to enter the particles by capilary attraction, thereby giving the moisture opportunity to become evenly distributed throughout the whole mass.

In air drying as in that by waste heat, additional time allowed is returned in brick free from internal and external cracks. Slow air drying should continue until the brick has set. The waste heat should continue until all mechanical moisture has been evaporated.

In the kiln, the initial burning should come slowly and consist of driving off all water of crystallization and the organic matter.

Final Burning.

The bricks are thoroughly oxidized. The elements are driven together. Various compounds of aluminum, silicon, iron, titania, sodium, potassium and calcium are collected into fewer compounds, which means a reduction in number of impurities, therefore raising the melting point of the brick. Here we have the time element as firing cannot be rushed. The great number of impurities occurring as colloidal matter, or otherwise in suspension, with moisture give the clay its bond. These materials slag first and because they are in such finely divided condition, hold the real clay particles of the structure together. As they slag they become purified, rising in melting point as lesser compounds are formed and finally, congeal with the principal clay particles in a partially vitrified mass at a temperature ranging from 2600 to 2900 degrees F.

Furnace Seasoning.

The refractory maker is progressing. Let the operating man do likewise; seasoning his furnace roof in particular if he desires it to last. If the furnace operator is careless he will bring his furnace right up to heat, at say 3000 deg. F. He has gone considerably beyond the melting point of the bonding material of the brick structure. The brick softens not because the true clay particles lack refractoriness but because the bond has not had time to slag with them at the minimum temperature. This means that the melting point at which firebrick should be burned, is at the maximum temperature to which it will be submitted when in actual service. Now, while slag action is on, he shuts down or chills his furnace and becomes familiar with spalling.

The refractory manufacturer cannot afford to operate his kilns at a temperature equal to the maximum obtained in furnace practice. When he has eliminated shrinkage and obtained the necessary bond, his part of the work is finished. By carefully raising the temperature on the initial heat in particular, the furnace operator will be adding a slight but vital degree of burning which is impractical to obtain at the kilns on account of cost.

Once the skin is properly formed, the brick will largely take care of itself for the reason that excess heat added to the brick will be largely lost through radiation.

Conclusions.

There appears to be no limit to the varied experiments and research which will be made with steel. There are just as many variables which enter into the manufacture of high grade firebrick and we are on a rising tide of improvement in the development of this important commodity, of which nearly one billion are consumed annually in the United States.

Power Progress During 1922

Following a Most Unauspicious New Year, Unexpected Developments Have Proceeded Rapidly. The Great Coal and Railroad Strikes Helped Rather than Hindered. Sustained Interest in Pulverized Firing. Motor Drives Permit Consolidation of Large Generating Units.

By F. J. CROLIUS*

NINETEEN hundred and twenty-two will take its place in industrial history as a most remarkable year in many respects. Unemployment at the opening of January 1922 was serious, only slight improvement over January 1921 being recorded.

Building contracts were being placed ultra-conservatively, sheet steel and tin plate production was consequently but slightly better than the preceding new year; railroad car surpluses were reported at or near historical maximums; indicating light buying. Automobile activity was scraping bottom.

Not only has the American power producer interested himself in improvement and concentration, but Europe and Canada as well have taken the hurdle of constantly increasing fuel and labor costs by adopting the best from engineering progress.

Larger unit boilers have been adopted; stokers have become a natural selection, instead of a skeptical one, pulverized firing records a number of sizable commercial installations, no longer considered as experimental. Electric boilers have been built up to 1,000 hp. sizes.

Prices of pig iron, open hearth billets, and structural shapes were at or near the lowest point known since prewar days; world trade conditions were still chaotic and exports of American steel products reflected this condition in seriously contracted totals.

Coke production was being maintained on a highly competitive basis, and coal production ebbed to the point of profitless operation.

Recognized statisticians were recording "bottom."

Under these conditions, power in its various manifestations began an uncertain year; construction or expansion ideas seldom comprehend the necessities of power until the eleventh hour, so power developments were held in abeyance. With the turn of the New Year, fundamentals made a decided change. A glance at curves shown in Fig 1 will emphasize the point. Business, which had been hesitant, began expanding, went ahead, took advantage of abundant cheap money and production scales were rapidly increased. By early summer unemployment hardly existed, the cry of labor shortage was heard universally. Then came the six months' coal strike, and the serious railroad shopmen's "vacation" with their attendant and consequent fuel, labor, motive power and equipment stringencies.

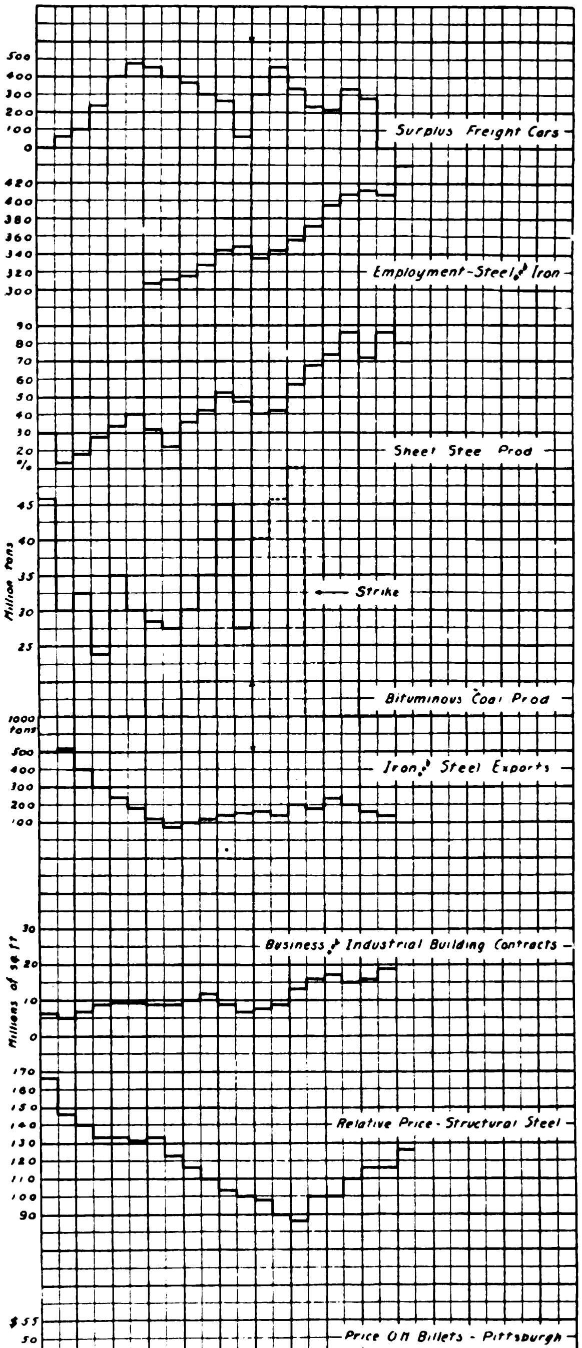

Fig. 1—A series of monthly production and cost curves which indicate the change of industrial trend at or near the New Year.

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*Engineering Editor.

These emphasized the power problem and with the settlement of these difficulties, extensive campaigns for power developments and consolidations may fairly be said to be permanently launched.

Steel Mill Power Demand Insistent.

Many industrial organizations have carried out well matured plans, and a large number of important installations are already in service. Operating difficulties under the unusual conditions showed the necessity of ACTION.

Too many small, scattered, low efficiency high-man power plants exist as a relic of "cheap coal and plentiful labor" days. These are gradually disappearing as they are no longer subject to temporary repairs, but are scrapped, to be replaced by large units.

Better Designed Plants Being Built.

New plant construction invariably shows the influence of power studies. No longer is the "driving source" left to conjecture, often it receives first consideration. The result is a better balanced operation, higher power factor and lower costs.

The heat balance period has arrived.

As an example of this prevailing tendency, the following comparison between stokers and pulverized firing under new boilers, duplicates of each other, and operated by the same personnel, is illustrative:

RESULTS OF TESTS ON POWDERED COAL AND STOKER FIRED CONNELLY BOILERS AT THE CREEK PLANT

Whitaker-Glessner Company, Wheeling, W. Va.

Test on	Powdered Coal	Stoker Fire
Date of Test (1922) Fuel Burning Equipment	Aug. 22nd Aero Pulverizer	Aug. 23rd Westinghouse Stoker
Heat Balance in Per Cent		
Loss due to moisture in coal	.22	.24
Loss due to burning of hydrogen	4.13	4.40
Loss due to moisture in air	.25	.28
Loss due to heat in dry flue gases	9.30	13.20
Loss due to carbon in ash		4.22
Loss due to radiation (assumed)	5.00	5.00
Total loss in heat	18.90	27.34
Efficiency of boiler and stoker	81.10	72.66
The heat balance was calculated on the basis of coal analysis as submitted by the Pittsburgh Testing Laboratory which are given below:		
Ultimate Analysis of Coal per cent by weight—Hydrogen	4.74	4.72
Carbon	68.08	67.84
Nitrogen	1.33	1.26
Oxygen	7.07	7.19
Sulphur	4.87	4.84
Ash	13.91	14.15
Btu. per ℔. dry coal	12,647	12,623
Analysis of Ashes:		
Carbon in ashes per cent		29.83
Ash per cent		68.22
Btu. per ℔. dry ashes		4699
The average of the principal results obtained during the tests is as follows:		
Total water evaporated, ℔s in 24 hours	1,108,756	1,205,000
Total coal used, ℔s. for 24 hours	105,352	125,567
Equivalent evaporation from and at 212 deg. F. per ℔. coal ℔s.	11.2	10.2
Boiler efficiency corresponding—per cent	86.1	77.3
Average rating developed during test period of 24 hours—per cent	172	186
Flue gas analysis, per cent by volulmes—CO2	14.4	13.7
O2	4.0	4.4
N2	81.6	81.9
Temperature of feed water—deg. F.	208	212
Temperature of flue gas leaving boiler deg. F.	470	649
Room Temperature—deg. F.	77	85
Average steam press ℔s. gage	190	190
Average Superheat deg. F.	27	20
Moisture in coal—per cent	2.08	2.25

These tests were conducted by Mr. H. O. Siebert of the Bethlehem Steel Company, Consulting Engineer.

Mr. Seibert's conclusions are interesting.

Conclusions.

1. Greater Efficiency, mechanical simplicity and ease of control justify the change that has been made in the plant by substituting pulverized coal equipment for the stoker equipment. Even if the fuel efficiency of the two installations were equal there still would be the liability of breakdown and labor trouble connected with the one and not so much with the other, and these factors alone would influence any experienced operator of boiler plants.

2. No boiler plant can hope to secure continuous effiiciency if it be complicated mechanically and dependent upon the good will of the fireman. To secure good results continuously the plant must offer an incentive to the operator by making his task as light as possible and giving him control apparatus which can easily be understood and operated. This the writer considers as having been well taken care of in the powdered coal installation.

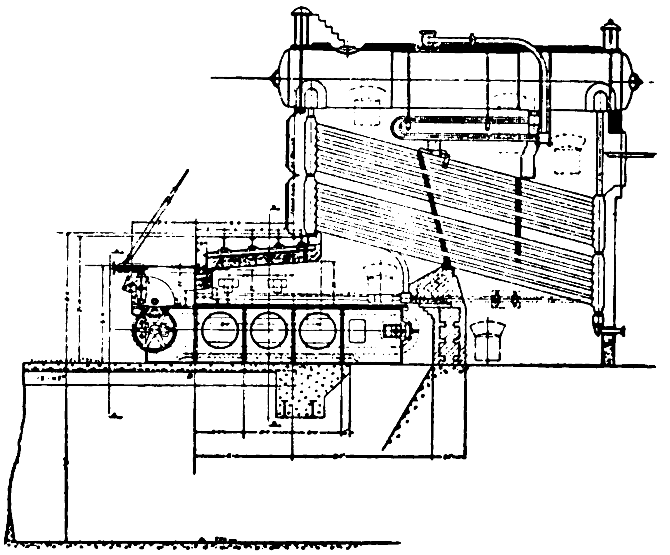

Fig. 2—Shows the most recent forced-draft chain-grate stoker. The three circles shown on the stoker frame are direct connected turbo-blowers.

Combustion.

Progress in steam generation has not been greater than the progress in combustion upon which high efficiencies depend. The importance of chamber-capacity is now recognized, and 1½ to 2 cu. ft. per developed hp. is now specified.

Forced blast burners, closely regulated and controlled for burning blast furnace gas, have very largely superceded the many types of natural draft aspirating burners. Such burners require a pre-combustion chamber, preferably of small size and with intimate ignition surfaces, and with natural expanding lines, so that gas and air mixtures may progress evenly without lanes or eddies.

So well defined is the progress in this important direction that a recent survey by one large corporation accepts as a premise to all its conclusions an operating boiler efficiency of 80 per cent wherever blast furnace gas is burned.

The conversion of coke-breeze into power, burning this difficult low value fuel on forced draft chain grate stokers continues as best practice, with a number of installations designed for high ratings being installed in important blast furnace plants.

Fig. 2 shows the most recent development of forced-draft chain grates. This stoker was designed and built to replace natural draft chain-grates. Instead of the usual slow speed fan and costly duct system, formerly employed, high-speed turbo-blowers placed directly on the furnace chamber structure furnish an adequate supply of easily controllable air. Greatly reduced cost of installation is claimed together with wide range of operation.

Wall Construction.

The very large boiler units now found necessary to low cost, high efficiency, have brought to the foreground the question of *wall construction.* Up to the last few years, very little stress was laid upon this feature. Almost any kind of wall was considered good enough, usually an ordinary outside envelope of hard brick, an inner lining of fire brick and often an intermediate layer of low conductivity material. Such a wall construction is however structurally weak.

Ported walls are not much stronger, and will doubtlessly give place to walls held in place by structural members, with subdivisions into sections for expansion and contraction allowances, or by suspended tile construction similar to recognized flat arches. Such wall structures are naturally higher in first cost, but lower in operating costs, which must ultimately be a charge against actual power costs. Excellent examples of such walls are now in operation, usually with sealed outside envelope, either of cast iron flanged sections or steel plate panels.

The radiation factor incident upon large boiler operation at high ratings with excellent combustion conditions, designed walls and sealed envelopes is now very low, not far from 1 per cent. When this is compared to the radiation found in small boilers at low ratings with the type of construction incident to such units, radiation of from 4 to 12 per cent the value of this step in advance will be recognized.

Pulverized Firing.

Pulverized coal firing continues to become accepted practice, and under favorable auspices. Instead of suffering under the handicap of being considered in the experimental class, complete plants are now being designed and put into operation. The difficulties are now well understood and engineering knowledge has been gained so that undesirable features can be eliminated and the desirable features taken advantage of.

The whole process is so flexible that various methods are being employed.

Some favor the indirect distribution method which has advantages where boilers are an incident in the total fuel scheme as for instance in a sheet mill, with heating requirements highly important, others favor the direct method in any of its various combinations. However, in large boiler units, of 1,000 hp., or over, where the entire product of a standard pulverizing mill can be absorbed by an individual boiler unit, *cost* must ultimately be the determining factor, and costs are definitely in favor of the direct method.

The accompanying cross sections give a clear idea of

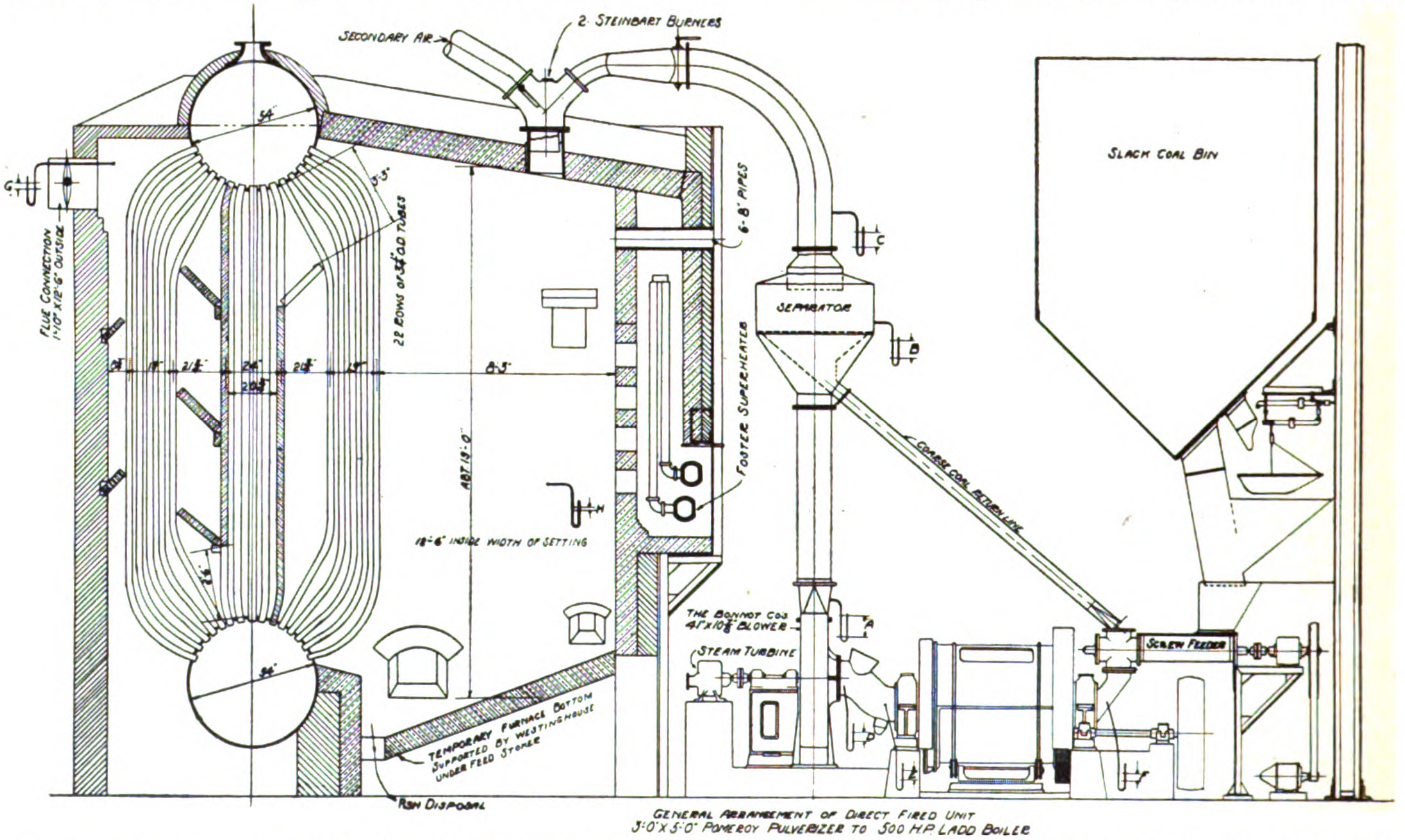
2 Steinbart Burners
Secondary Air
Slack Coal Bin
54"
5'-5"
22 Rows of 3¼" O.D. Tubes
6-8" Pipes
C
G
Flue Connection 1'-10" x 12'-6" Outside
Separator
B
8'-5"
Foster Superheater
Abt 19'-0"
Coarse Coal Return Line
H
18'-6" Inside Width of Setting
The Bonnot Co's 41" x 10⅝" Blower
A
Steam Turbine
Screw Feeder
36"
Temporary Furnace Bottom Supported by Westinghouse Under Feed Stoker
Ash Disposal
General Arrangement of Direct Fired Unit
3'-0" x 5'-0" Pomeroy Pulverizer to 500 H.P. Ladd Boiler

Fig. 3—Shows a typical installation of pulverized fired boiler. A Slow-speed ball-type mill takes undried slack coal direct from the usual overhead bunker, and the exhauster fan froces the air and powdered coal direct to the top of the combustion chamber. Very slight furnace alterations were necessary.

DATA AND RESULTS OF EVAPORATION TEST AT HAMMERSMITH ELECTRICITY WORKS

	Test No. 1	Test No. 2
Type of boiler	Sterling	Sterling
Location	H. B. C. Works	H. B. C. Works
Kind of furnace	P. F. P. Co.	P. F. P. Co.
Kind of fuel	Semi-anthracite	Semi-anthracite
1. Date of test	January 19, 1921	May 10—11—12—13
2. Duration of test	6½ hours	72 hours
3. Water heating surface	9861 sq. ft.	9681 sq. ft.
4. Super heating surface	1120 sq. ft.	1120 sq. ft.
5. Total heating surface	10981 sq. ft.	10981 sq. ft.
6. Volume of combustion space		
7. Ratio of water heating surface to volume of combustion space		
8. Ratio of total heating surface to volume of combustion space		
Average Pressures		
9. Steam gauge	165 lbs per sq. inch	164.8 lbs.
10. Draft between damper and boiler	0.5 in. of water	½ in. of water
11. Draft in the furnace	0.25 in. of water	¼ in. of water
Average Temperatures		
12. Feed water temperatures	53 deg. F.	62.7 deg. F.
13. Preheated air	280 deg. F.	284 deg. F.
14. Superheated steam at valve	550 deg. F.	615 deg. F.
15. Gases under superheater	885 deg. F.	894 deg. F.
16. Gases before recuperator	500 deg. F.	502 deg. F.
17. Escaping gases	415 deg. F.	415 deg. F.
Fuel		
18. Total weight of dry coal fired	20,000 lbs.	278,180 lbs.
19. Total coal used in drier furnace	560 lbs.	5,097 lbs.
20. Total energy consumed by all equipment on preparation and firing of pulverized fuel	400 kw.-hours	5,133 kw.-hours
21. Coal equivalent for this energy at 3.9 lb. of coal per kw.-hr.	1,560 lbs.	14,384 lbs.
22. Total dry coal fired plus drier coal, plus coal equivalent for energy	22,120 lbs.	297,661 lbs.
Fuel Analyses		
23. Fixed carbon	66.4 %	65.69%
24. Volatile matter	13.28%	14.57%
25. Moisture	7.92%	8.74%
26. Ash	20.58%	18.04%
27. Btu. per lb. dry coal	12,134	11.750
28. Btu. per lb. combustible		
Flue Gases		
29. CO2	12.2%	12.8%
30. CO	nihil	0.0
31. O2	7.0%	6.2%
Feed Water		
32. Total weight of water fed to boiler	173,200 lbs.	1,810,200 lbs.
33. Factor of evaporation	1.3	1.34
34. Total equivalent evaporation from 212 deg. F.	225,582	2,425,670 lbs.
Hourly Quantities and Rates		
35. Dry coal fired per hour	3,077 lbs.	
36. Total coal consumption per hour	3,403 lbs.	
37. Water evaporation per hour actual	26,492 lbs.	25,142 lbs.
38. Equivalent evaporation per hour F and A 212 deg. F.	34,700 lbs.	33.690 lbs.
39. Boiler hp. developed	1,005	967 hp.
40. Rated capacity per hour f and a 212 deg. F.	40,000 lbs.	40,000 lbs.
41. Rated boiler hp.	986	986
42. Percentage of rated capacity developed	102	99
Economy		
43. Water fed per lb. of coal as fired	8.60 lbs.	7.264 lbs.
44. Equivalent evaporation f and a 212 deg. F per lb. of coal as fired	11.28 lbs.	9.731 lbs.
45. Water fed per lb. of coal consumed	7.78 lbs.	6,986 lbs.
46. Equivalent evaporation f and a 212 deg F. per lb of coal consumed	10.19 lbs.	9,386 lbs.
Gross Efficiences		
47. Calorific value of one lb. of dry coal	12,134	11,750 Btu.
48. Efficiency of boiler and furnace including drier coal and coal equivalent for energy	78.15%	80.32%

Note:—The coal used in the test was measured by means of calibrated feed screw on the pulverizer. This screw was checked at various times and the difference was less than ¼ per cent. The pulverized coal level in the storage bin was determined very carefully at the beginning of the test, and at the end of the test this level was restored by pulverizing sufficient coal to bring it up to the initial reading. The actual amount of coal consumed by the boiler was the amount actually pulverized during the test.

A calibrated water meter was used to measure the feed water. This meter was checked at the plant of the maker and also at Hammersmith's Generating Station. All the customary precautions to obtain accuracy were observed, and very close attention was paid in the pulverizing station.

TEST PULVERIZING EQUIPMENT—MAY 10-13, 1921

Moistures and Fineness

1. Moisture of coal entering drier—per cent	8.74
2. Moisture of coal leaving drier	
3. Moisture of coal leaving pulverizer—per cent	1.3
4. Fineness of pulveized coal—200 mesh—per cent	81.5
5. Fineness of pulverized coal—100 mesh—per cent	96.5

Total and Hourly Quantities

6. Total coal as received, long tons	124.2
7. Total coal as used in the drier tons	2.26
8. Total coal as received at drier	121.94
9. Total coal as per hour of drier operation as received	
10. Total coal pulverized, coal from drier	111.27
11. Total dry coal fed by the pulverizer feed screw at 20 lbs. per revolution	105.37
12. Coal pulverized per hour, as received from drier (18.5 pulv. hrs.)	6.02
13. Rated capacity of pulverizer—10,000 lbs.	4.46
14. Coal pulverized per hour based on pulverizer feed screw	5.69

Electric Energy and Coal Consumption

15. Total energy consumed by pulverizer and exhauster kw.-hr.	1124
16. Total energy per pulverizer hour	60.8
17. Total energy consumed by blower and generator set	3640.0
18. Total energy per distributing hour	50.8
19. Total energy consumed by drier, drier feed screw and belt conveyor	369.0
20. Total energy consumed by all equipment on preparation and firing of pulverizer fuel—kw-hr.	5133.0
21. Energy per ton of coal, as received, kw.-hr.—grand total	42.07
22. Coal equivalent for this energy at 2.75 lbs. coal per kw.-hr.—lbs.	115.7
23. Total coal used in drier furnace—lb.	5097.0
24. Coal per ton of fuel dried, (based on coal as received)—lbs.	41.7
25. Total coal and equivalent consumed in preparation and firing of one long ton of pulverized coal—lbs.	157.4

SUMMARY OF RESULTS

Electric Energy and Fuel Consumption per ton of Coal Pulverized

1. Total energy kw.-hr.	42.07
2. Coal equivalent at 2.75 lbs. per kw-hr.	115.7
3. Coal consumed in drier furnace, lbs. per ton of coal dried	41.7
4. Total coal and equivalent lbs.	157.4
5. Gross efficiency less deduction for total coal and equivalent—Item 4—per cent	75.11

POWER CONSUMPTION OF VARIOUS MACHINES AT HAMMERSMITH PULVERIZED COAL PLANT

Distributing blower	
Speed	700 rpm.
Static pressure	10.25 inches
Output	10,000 cu. ft./min.
Power	48 hp.
60-in. Exhauster	
Speed	950 rpm.
Power	16 hp.
36-in. Pulverizer	
Speed	170 rpm.
Output	8,800 lbs. per hour
Fineness	81.5%—200 mesh 96.5%—100 mesh
Power	57.5 hp.
5 ft. by 50 ft. drier	
Speed	5 rpm.
Output	5 ton per hour
Power	7 hp.
Dry Coal Feed Screw	
Output	5 ton per hour
Power	4 hp.
Drier Feed Screw and Belt Conveyor	
Output	5 ton per hour
Power	3 hp.
Generator set	
Power	12.5 hp

tendencies shown in recent boiler installations. Fig. 3 shows a pulverized fired vertical bent-tube type boiler, with low speed pulverizer.

The accompanying data of one of England's latest power-house improvements, showing three tests run on pulverized coal boilers will serve to prove that 80 per cent efficiency is not a matter of geographical location.

Steam Consuming Units.

Progress in steam consuming units has quite kept pace with generation developments.

Unaflow.—The unaflow has taken its place, and European practice finds itself justified. Unaflow engines of all sizes are giving excellent performances, under definite guarantees. Power engines and mill engines, both condensing and non-condensing compare very favorably with turbines of corresponding size and duty.

One installation of very large unaflow type (approximately 13,500 hp.) designed for a blooming mill drive will be in operation early in 1923 and great interest centres about its performance. Expectations of service, rolling average five ton ingots, of 90 revolutions forward and 90 revolutions back in 1½ seconds give some idea of its remarkable possibilities.

Turbines.—Steam turbines have shown development in refinements rather than magnitudes.

The question of materials has received much attention. Improvements in blading has resulted through the use of Monel and stainless steel; corrosion and erosion are no longer the serious factors they formerly were.

Vibration troubles have been overcome through better designed wheels and buckets.

European Influences.

If there is any single defined tendency that European practice suggests, it must be the adoption of the Evase stack, the shorter stack with the Venturi line.

Many large central power houses in France and Germany can be identified by the shape of the stacks. Internally and in cross section, they differ but little from American, but externally, their different appearance is marked.

Many claims are made for this rather unique application of the functioning of a natural law. Primarily, of course, they are cheaper to build, and the investment in air handling equipment is lower; how much less power is required is a question, although statistical data is given, which greatly favors the Venturi stack. In comparison with induced draft fans, there can be no question as to lower power consumption, because the most efficient type of blower can be selected which can operate under ideal conditions, rather than a limited selection in induced draft constructed fans, usually very inefficient types, and which operate under most difficult conditions.

Fig. 4 shows a cross section of Venturi line stack applied to natural draft, chain grate stokered boilers, which was installed for emergency purposes and which met the emergency.

The problem was to keep in operation eight boilers, served by two stacks, four to each boiler, during the rebuilding of one stack.

A centrifugal blower, designed to develop 16 oz. pressure, driven by a 40 hp. steam turbine was connected to the air duct at the base, and the pressure air carried up to the nozzle at the orifice located some 40 ft. from the stack-base. The two separate breechings, each back of a pair of boiler batteries, were interconnected.

Although the blower failed to deliver a pressure greater than 6½ inches at the discharge flange, due, perhaps to a wrong orifice diameter, sufficient draft was developed over the fire in all eight boilers to keep these boilers at their average ratings while the stack construction work progressed.

Electrical Power Developments.

Many improvements are seen in the existing forms of electrical apparatus.

Transformer practice has been improved by the application of the oil conservator to smaller units. A new cooling system has been devised for localities where water is scarce.

Non-oil throwing circuit-breakers, which are explosion proof; semaphore protection for plunger type over load relays, and a multi-contact potential relay for controlling up to ten circuits at once.

The electric steam generator shows possibilities where industrial plants control hydraulic or cheap waste heat power, and where steam is still required for plant use.

A Dream Fulfilled.

The Hydrautomat, a method of lifting water without power, may exert its influence in the near future. If the tests now being conducted by the government substantiate the claims of Thomas G. Allen, the inventor, the problem of power will be vitally simplified.

All that is necessary is a flowing stream of water, and that is one thing that nearly every steel plant possesses, or should possess.

In conclusion it must be admitted that power as a general subject has reached its proper place in the Industrial scheme.

The years of investigation, of comparison, of engineering discussion have borne fruit, until today a wealth of data exists, which, intelligently used, will prevent the enormous wastes which have here-to-fore been accepted as inevitable. Although the sources of power in steel plants differ widely from central station plants, i.e. blast furnace and coke oven gases, open hearth waste heat, etc., the general characteristics of the production scheme remain the same. It is only a question of time until steel plant power houses will be central stations, with equal efficiencies and lower costs.

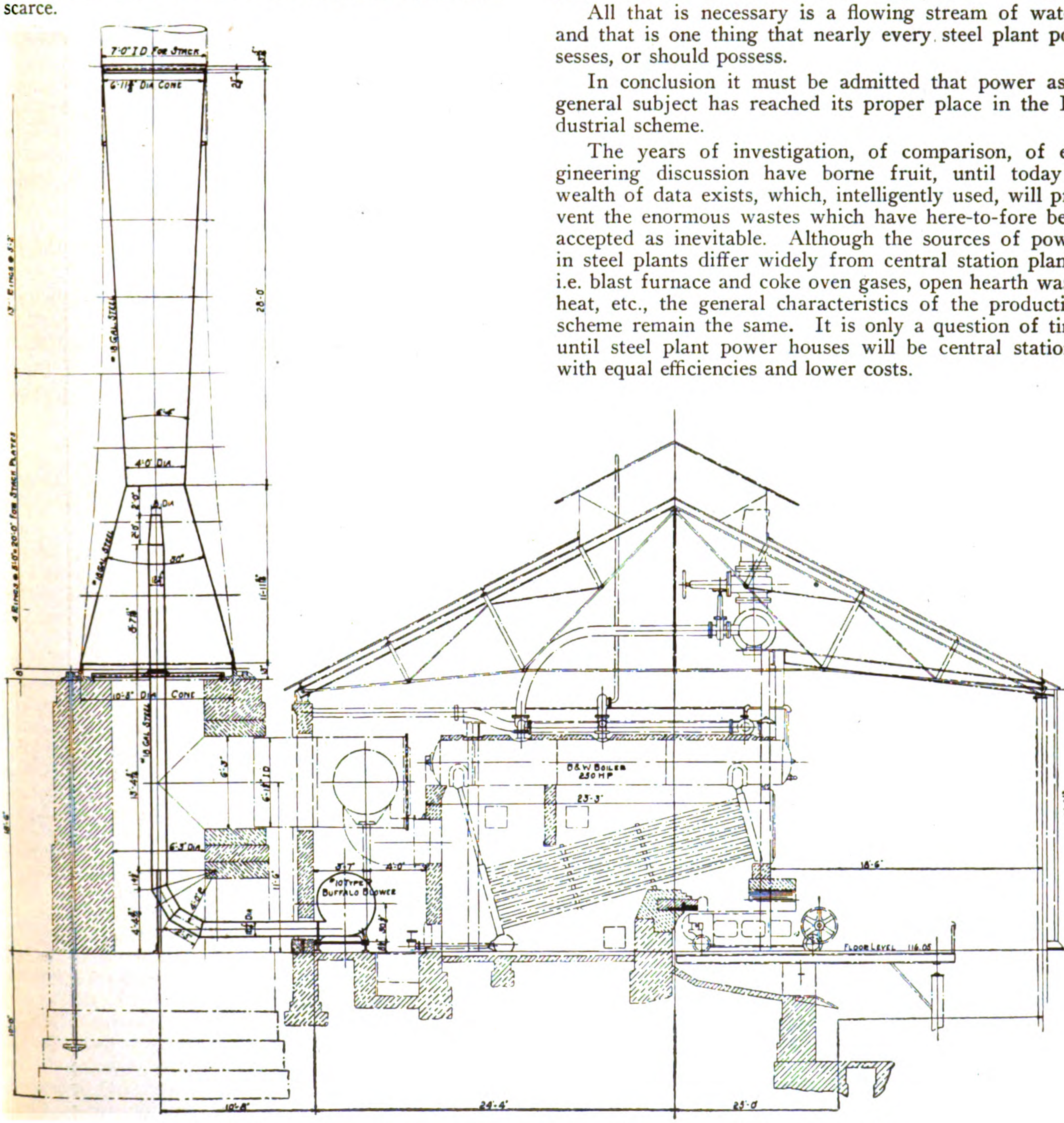

Fig. 4—Shows the application of Evase construction to an existing stack. The advantages of forced draft were secured with small expense. Note small combustion chamber considered adequate 20 years ago.

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Trend of Power Development as Affecting Steel Mills

Super-power Systems are Forcing Small Isolated Plants to be Abandoned. A Discussion of Various Refinements—Efficiencies Must be Comprehended on Comparable Basis.

By BRYANT BARRISTER*

THE trend of central station operation has been toward the combining of numerous small stations into a fewer number of large stations, where advantage may be taken of: (1) high grade superintendence and operating personnel without involving high overhead costs, (2) large units designed for high efficiency without involving excessive first cost or fixed charges (per unit of capacity installed), (3) indicating and recording instruments, (4) automatic control systems, and (5) other refinements may be used without materially increasing the capital outlay. The result of these factors is a lower wholesale power rate.

Isolated Plants Buy Cheaper Power.

This downward trend of purchased power rates makes central station power more attractive to both large and small consumers, and many isolated plants have been abandoned in favor of purchased power. The effect of this increased load on the central station, makes it possible to enjoy to a still greater extent the advantages previously enumerated, which promote further decreases in wholesale rates. This process is cumulative, and its effect is well demonstrated by the downward trend of electric power rates in the Pittsburgh District for the past twelve or fourteen years, even in the face of increased fuel and labor costs.

These conditions force the isolated consumer who does not go to purchased power, to install modern equipment or devices which will permit of higher operating economy, in order to generate power as cheaply as it can be purchased from the central station.

Concentration Into Larger Units.

In the rehabilitation of power systems, large corporations with numerous plants grouped is geographic proximity must consider the possibilities of centralizing their generating equipment into "super-power" systems, in order to benefit from the higher economy of large generating stations and to permit the economic dispatching of power, so that an excess of by-product or cheap power at one plant may be used at other plants, where virgin fuel would otherwise be required.

Ratings.

As coal costs increase, the economical rate at which boilers can be operated decreases, due to the fall of combined efficiency at high rates of operation; this due largely to higher escaping gas temperatures. Additional boiler surface used to extract more heat from the gas does not pay, as the surface operating at the temperature difference between escaping gas temperature and steam temperature does little work. The advent of the steel tube economizer, however, has changed conditions, making it possible to extract heat from gases at low temperatures economically, so that even with high fuel costs, high ratings are and will be more common.

Economizers.

Economizers are justified in nearly every case, so far as theoretical results are concerned, but the real problem is, obtaining in actual service the favorable conditions for the operation of the economizer, upon which its installation is justified. Until recently, economizer operation was accompanied by excessive air infiltration and low gas velocities, resulting in a low rate of heat transfer. Steel tube economizers make it possible to use steam jets for cleaning the exterior surfaces, and a further refinement in the nature of cast iron armor rings on the exterior surface of the tubes, permits of washing down with water without tube corrosion. These refinements permit the elimination of tube scrapers, and due to the elimination of air infiltration through holes in the casing for the operation of the scrapers, a gas-tight casing may be applied which permits the use of a high draft in the economizer, and high gas velocity through it, resulting in high rates of heat transfer. A further development in tube construction is now on the market which involves the use of corrugated cast iron armor rings on the steel tube, which effect a saving in weight, bulk, head room, capital charges, and with the elimination of air infiltration and the possibility of high velocities as previously mentioned, these economizers become a very attractive proposition.

The development of steel tube economizers was hampered by corrosion of the water side surface, due principally to the action of dissolved gases in the feed water. The advent of water treating equipment in the nature of gas extractors has overcome this difficulty, and this type of equipment is being installed in modern stations.

Powdered Fuel.

Undoubtedly the one development which is creating the most interest at the present time is that of powdered fuel, although this field is not a new one. Numerous improvements have been made both in the method of pulverizing and in the method of utilizing the fuel, and efficiencies now being obtained threaten to challenge the standard types of stoker to a show-down. The recent trend seems to be toward direct firing, which eliminates the storage of fuel in the pulverized form and consequently the necessity of drying. Large and properly designed combustion chambers permit the use of a lesser degrees of fineness, with a consequent saving in power and maintenance. The fact that powdered coal and blast furnace gas require similar form of combustion chambers, makes powdered coal an admirable stand-by fuel to use in blast furnace gas-fired plants during gas shortage, and it is claimed that certain advantages tending toward high efficiency accure from the combustion of both fuels simultaneously in the same furnace.

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Turbo Blowers.

The design of turbo blowers has been developed to such an extent that they have become extremely attractive for blowing both blast furnaces and steel converters. Since the blower elements are essentially high speed machines, they are admirably adapted to high speed, direct connected turbines. The high blade speed permits the use of high steam temperatures and pressures with a smaller number of stages, resulting in a steam economy which is as good as is possible with a turbo generator several times as large. When this fact is considered, together with the saving of capital investment, repairs and maintenance, operating labor, etc., it is usually found that the turbo blower is a better financial investment than either the gas engine—or steam engine-driven tub. Users of turbo blowers claim more uniform and better operating results from their furnaces, and this machine is coming into quite general use.

Selection of Other Mechanical Equipment.

In the replacement of existing equipment or the installation of new equipment in a plant, care should be exercised to see that the new equipment is properly coordinated with the rest of the plant. An instance is known to the writer, where an economizer was installed in the flue carrying waste gases from a battery of nine existing boilers to a common stack. When the installation was started, it was found that the boilers would carry only a small fraction of their former normal rating, due to the combined effects of increased draft loss and lower temperature of gases in the stack. It also happened that, on account of cramped conditions, an induced draft fan could not be installed.

In comparing efficiencies of various types of equipment, the engineer must ascertain whether the efficiencies are really comparable, that is whether they have all been brought down to a common basis. For example, some data were recently shown to the writer which indicated that a particular type of furnace had shown on test a combined efficiency of 82 per cent when burning coal under a Standard type of boiler. At the outset, the results looked promising. Further examination of the data, however, showed that the steam pressure was 87 lbs. gauge, capacity, developed 90 per cent, and terminal temperature difference between escaping gases and steam temperature 50 deg. Modern practice involves pressures around 275 lbs. and ratings around 250 and 275 per cent of builder's rating. Under these conditions, the steam temperature would be 85 deg. higher than under the test condition, and the terminal temperature difference would be about 150 deg., so that if the same boiler were to operate under conditions corresponding to modern practice, the escaping temperature would be about 185 degrees higher, which corresponds to approximately 5.3 per cent difference in efficiency. The efficiency of the boiler under the modern conditions would then be less than 77 per cent, which can be obtained under test conditions by most any of the common types of fuel burning equipment.

Cost Comparisons Necessary.

In the selection or comparison of any equipment, it is important that glaring thermal efficiencies do not blind the engineer to such an extent that he lose sight of the ultimate-economic efficiency. There are many possible improvements which may be made in equipment, which would increase the thermal efficiency of a plant, but many of them would cost so much that the capital charges and operating costs against the equipment would more than equal the saving effected by the change. All comparisons should, wherever possible, be resolved into total costs per year, including capital charges against the investment, plus the annual costs for its operation, and these figures are the criteria as to the relative worth of the various types of equipment. Of course, merits such as accessibility, operating advantages, reliability, etc., which cannot be easily capitalized, should also receive due consideration, but the economic efficiency is usually the most important point of consideration.

In general, the trend of power equipment for many years has been along lines of expansion and refinement, rather than involving radical changes of design, and most of the engineers' problems today are along the lines of selection of the equipment which will give him the most service per dollar invested.

Synchronous Motors

By E. FRIEDLANDER*

A Solution for Increasing Load Without Incurring Great Expense. Many of the Faults of Early Design Have Been Eliminated. Advantages Over Induction Motors.

Usually when a.c. motor drives were installed in the past in steel plants, induction motors were selected. In order to do the work satisfactorily, and approximate speed-characteristics of d.c. motors, such drives were generally overmotored, i.e. run on the average at light loads. Therefore, efficiency and power-factors, where a considerable number of such installations were running on a system, were very low.

The magnetizing current necessary for such motors may amount to as much as 30 per cent of the total current in the system regardless of load-conditions and would prevent generating stations and transmission lines from handling full-load without overheating.

Possibility of Increasing Load.

Where an addition to such systems is under consideration, it will pay to investigate, first, whether additional load could not be carried by the present system without adding to the old equipment. There are many cases where through the judicious application of synchronous motors and condensors in the system, its power-factor and regulation can be greatly improved and the efficiency of the entire transmission system considerably increased. In such a way increased capacity could be gotten from the old system at less expense and in quicker time with subsequent saving in the operation of the plant, than when installing machinery.

Where electric current is bought from central stations, it is to the interest of both consumer and central stations to maintain as high a power-factor as will prove economical. In recent years contracts for large amounts of power include clauses to the effect that the power-factor must be maintained above a certain amount to get the lowest rate; otherwise price per kw. increases as power-factor decreases. This additional cost of purchased power would in many cases more than pay for the apparatus correcting poor power-factors.

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Synchronous Motors Greatly Improved.

The best means of improving such systems is the installation of synchronous apparatus in the system. Not so long ago synchronous motors were considered not desirable for doing any mechanical work or even power-factor corrections on account of their difficulty to start under load, their necessity for using d.c. excitation and their tendency to drop out of step whenever an unusually heavy shock occurred in the system.

The design and construction of the synchronous motor of today have been improved to such a degree, that its use has been extended to a great many applications, where its application has not been thought of before. The modern synchronous motors have practically the same characteristics as the squirrel-cage induction motors, i.e. about double normal torque at the pull-out point. Their efficiency is practically the same from full-load to half-load; even at light-loads, when induction motors operate at a very low power-factor, synchronous motors will improve power-factor on the transmission-line.

Assuming constant frequency synchronous motors run at a constant speed regardless of load; however, they are liable to drop out of synchrony through great drop in voltage and will only pull back in step, if the load is partly decreased. There is no doubt that some day synchronous motors can be built which will have as high a degree of stability as induction motors.

Characteristics.

One of its most valuable features is its ability to operate at unity power-factor and at the same time compensate for the reactive currents of other apparatus.

By means of compensated squirrels-cage windings, synchronous motors are now able to develop sufficient torque on drives, where starting requirements are quite severe. The starting of any motor-driven machine under full or near full load is the most severe condition motor is subject to; this is especially the case with synchronous motors. It is often, therefore, advisable to reduce the starting torque as much as possible as for instance through mechanical unloaders on air-compressors, closing of discharge valves on pumps, clutches on line shafts, etc. It must not be over-looked that although the starting torque of synchronous motors may be made equal to that of the squirrel-cage induction motors, it decreases rapidly as speed approaches synchronism.

The application of a motor to a certain machine involves not only a careful study of the operation the machine has to perform, but also of the characteristics of the motor applied to it.

Where frequent starting and stopping is required and starting must be done under full load, synchronous motors should not be used; also not where speed changes are required. The induced high potential across the field terminals of synchronous motors is a dangerous characteristic and must be watched, when coming in close contacts with such drives.

Advantages.

For certain installations synchronous motors have a number of other advantages over the induction motor, besides their faculty of being able to compensate for the reactive currents on the system. Their first cost is lower, especially at slow speeds, easier up-keep on account of bigger air-gap between stator and motor, simpler construction of machine, better efficiency especially on partial loads, and constant speed under all load conditions.

During the last few years the tendency towards using synchronous motors on a greater number of drives has been very noticeable such as on air-compressors, blowers, fans, motors-generator sets, tube mills, rubber mills, cement mills, rolls, grinders, crushers, pumps, line-shafting, conveyors, etc.

The application of synchronous motors can be recommended for the following installations:—

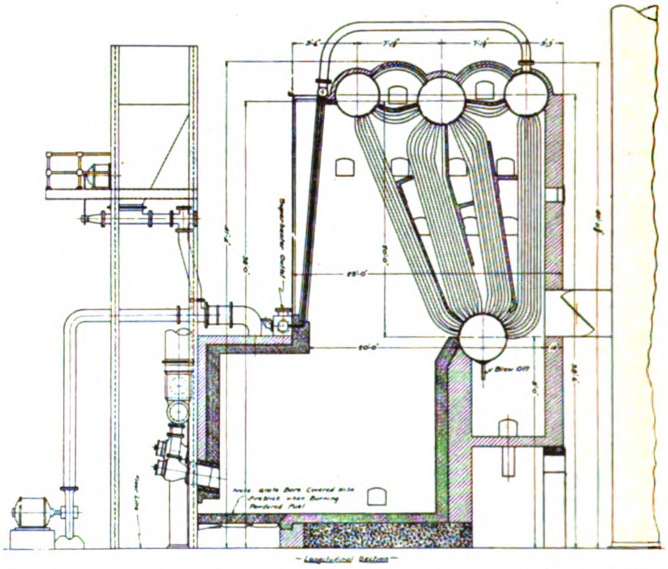
1. For drives where constant speed is desirable.
2. For drives where speed-changes or frequent reversals are not required, provided starting under full load is not necessary.
3. For compensating for reactive currents and improving power-factor of a system.
4. For driving motor-generators, frequency-changers or synchronous condensors.
5. For driving slow-speed air-compressors, if starting torque does not exceed 50 per cent of normal torque.

The Value of Raising Steam Temperatures

By JOHN R. LeVALLY*

Superheaters are Practical for Installation in Existing Boilers. Cylinder-condensation in Old Mill Engines Greatly Reduced, and Rolling Capacities are Correspondingly Increased. Higher Overall Efficiencies May be Expected.

Until comparatively recently the question of using superheated steam in steel mill practice has been limited to new installations, where the steam was utilized for the generation of power in turbines. With the steadily increasing price of fuel, the attention of steel mill engineers has been brought to the possibility of using a moderate degree of superheat on their present saturated equipment as a means of reducing steam requirements.



Combination blast furnace gas and pulverized fired boiler. Note the superheater in upper front boiler wall.

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*District Manager, The Superheater Company, Pittsburgh, Pa.

Heavy Condensate Loss in Long Lines.

In the majority of steel plants, steam is carried long distances from the point of generation to the engines and in several of the plants, two or more boiler rooms at considerable distance apart feed into the same system. While most of the plants have no accurate means of checking condensation losses between the boiler plant and engines, those that have made tests have found this loss sufficient to warrant investigation. In one plant with a monthly steam production of approximately 307,000,000 ℔s. they found their line traps discharging approximately 20,000,000 ℔s.or 6.5 per cent into the sewer, a total loss.

It has been found by experience that if the final temperature of the steam is not over 500 deg. F. no changes or special provisions will need to be made in present equipment to take care of the superheat, providing the piping system is flexible enough to take care of the additional expansion. In plants operating at 150 ℔s. pressure this allows from 100 deg. to 125 deg. of superheat being used without making any changes in valves or piping.

The saving in fuel effected by superheating existing equipment may be divided into three parts i.e., reduction in steam consumption of the engines, elimination of pipe line condensation and increase in boiler efficiency.

Savings Possible by Superheating.

1. *Steam Consumption.*—The first saving is by far the largest, amounting to from 12 per cent to 18 per cent of the steam used, depending on the type and condition of the engine. In slow speed rolling mill engines another advantage obtained through the use of superheated steam is the increased capacity. These engines usually run intermittently with the result that condensation losses are very great, particularly when starting. When superheated steam is used, this condensation is eliminated with the result that the full power of the engine is obtained on the first few revolutions and it is brought up to full speed in a much shorter time. In one mill this feature resulted in increasing the capacity from 40 tons to 56 tons in the same interval of time and in another the time required for a particular rolling operation was cut from 4½ minutes to a litte over 2½ minutes.

2. *Line Condensation.*—The second item of saving, elimination of pipe line condensation, is one that requires special study in each case and depends on the length of pipe line, size of pipe, insulation, and steam velocity, as well as steam temperature.

It is generally agreed that the greatest part of the friction loss in steam lines is due to particles of entrained moisture carried in the steam and to the drag caused by the film of moisture which forms on the inside of the pipe. By the use of superheated steam, both the moisture film and the entrained moisture are eliminated, causing an appreciable reduction in pressure drop. Figuring on a basis of Btu. radiated it may be found to be more with superheated steam than with saturated, in a particular instance, but, when figured on a basis of Btu. available for work at the other end of the line, the net result in the great majority of cases is greatly in favor of superheat.

3. *Higher Boiler Efficiency.*—The third item of saving, the increase in efficiency of the boiler, due to the introduction of additional heating surface, usually amounts to from 1 per cent to 2 per cent and it is the usual practice for English boiler companies to guarantee from 1 per cent to 1½ per cent higher efficiency on a boiler with a superheater, over a boiler alone.

Figuring on boiler capacity measured in the number of Btu. delivered in the steam, less coal will be required in a boiler equipped with a superheater than in the boiler alone the difference being measured by the increased efficiency of the unit.

This statement is often taken to refer to pounds of steam delivered, which of course is incorrect. Figuring on a basis of pounds of steam delivered, if the boiler and superheater combined efficiency were assumed to be the same as the boiler alone, the additional weight of fuel required to superheat the steam would be from approximately 3.1 per cent for 50 deg. of superheat to 10.6 per cent for 200 deg. varying slightly with feed temperature and boiler pressure.

Net Savings Must Include Above Factors.

It will be seen from the above that the actual net saving in fuel due to superheat cannot be figured as being equal to the reduction in steam consumption of the engines but must be figured as the difference between the additional fuel required to obtain the superheat after making allowance for the better efficiency of the boiler and superheater unit, and the saving in steam consumption.

While each plant is an individual problem requiring analysis, it is safe to say that there are very few plants operating at present on saturated steam used for power purposes that cannot reduce their fuel consumption from 5 per cent to 15 per cent by conversion to a moderate degree of superheat, without changing any of their present equipment, and the resultant return on the investment will range from approximately 40 per cent to 120 per cent based on $2.00 coal.

PULVERIZED COAL ON BILLET AND INGOT HEATING FURNACES

Engineers at the Ougree plant of the Societe Anonyme Ougree-Marihaye, France, report the following interesting operating results with pulverized coal fired on billet and ingot heating furnaces of the hand continuous type.

Two bar mill reheating furnaces heating steel billets for rolling into sheets, light rails and margin bars.

These furnaces were formerly hand fired with a very good grade of coal and consumed 73 kgs. (161 lbs.) of coal to heat each ton of billets.

They have now been changed to pulverized coal firing, using Quigley fuel system equipment, and the fuel consumption, per ton of billets heated, has been reduced to 35 kgs. (77 lbs.), or an actual saving of 84 lbs. of coal per ton of billets, which means a saving of over 12 tons of coal per day.

In the large rail mill they have also two furnaces heating ingots of various sizes, which have been changed from hand firing to pulverized fuel firing, using Quigley equipment, with the result that where formerly these furnaces consumed 48 kgs. (108 lbs.) of coal, per ton of ingots heated, they are now using powdered coal and consume only 15 kgs. (33 lbs.) per ton of ingots heated.

The ingots are charged hot at an average temperature ranging from 750 to 1100 deg. F. and discharged from the furnace at a temperature of 2280 deg. F.

The actual fuel saving is 75 lbs. of coal per ton of ingots heated, or a total saving per day of more than 15 tons of coal.

The Selection of Boiler Feeders

Centrifugal Pumps Now Possess the Reliability of Reciprocating Boiler Feeders Plus Economy in Space Required. Harmonizing Theory of Design with Operating Practice Required Years of Experiment.

By H. A. SHULTZ*

RECIPROCATING pumps have been used for many years to pump water into boilers and have given good service. They have, however, certain inherent faults which involve the outlay of much money and labor to keep them in good working order.

Disadvantages of Reciprocating Pumps.

1. There is the comparatively slow movement of the working parts, which results in large dimensions and heavy weights. Replacement parts are consequently expensive and require much labor for handling and putting into place. The slow movement of parts is considered, by some people, an advantage, with the thought that it reduces wear. However, experience has shown that high rotative speeds are less destructive than slow reciprocating movements, provided the higher speed parts are correctly proportioned and loads properly distributed.

2. The space occupied by the reciprocating pumps is often a serious handicap and naturally entails increased cost for ground covered and buildings and foundations.

3. The cost of packing renewals, valve re-grinding or renewals, rod renewals and other repairs is often a large item in the cost of operating a boiler plant, especially if the boiler feed water contains gritty substances, which is often the case.

Early Centrifugal Design Faulty.

Centrifugal pumps first attracted real attention as boiler feed pumps about 15 years ago. Not very many were in use at that time, but their use spread quite rapidly for a time.

However, in the early stages errors were made by designers, which cast reflection on these pumps for a time and made it appear that they were not sufficiently dependable for such important service. There was a feeling that they were too delicate and required too high class labor for their successful use. Manufacturers made the mistake of finding fault with trivial details in the operation and installation when actually the fault lay in the design of the machine.

Now, however, we have on the market a number of makes of centrifugal boiler feed pumps which are well designed and will give good service even under the adverse conditions that are prevalent in many plants in this country.

Successful Operation Depends on Design.

There is very little the operator can do to help or hinder the successful operation of a centrifugal pump, when it is properly designed and installed. There are usually only two bearings on the pump which require lubrication and two more bearings on the prime mover. If the latter is a steam turbine there is usually one more point of lubrication, viz., the governor. Therefor are five points requiring lubrication. These parts can be and should be designed so that they will require only occasional filling with oil. Other than these parts and occasional adjustment of packings, there is nothing for the operator to take care of after the machine has been started up.

The successful application of centrifugal pumps consequently lies principally with the designer and builder.

Motor-Drives Available.

Two sources of power are used for driving centrifugal boiler feed pumps, viz. the direct connected steam turbine and the electric motor.

The steam turbine is small, compact, simple in construction and can be operated safely at the speeds most desirable for the pump. It also is very flexible in speed and can be automatically controlled by simple devices.

The electric motor is also small, compact, and simple in construction, but it is not suitable for the most desirable pump speeds as a rule and is rather inflexible as to speed, requiring complicated control for automatic speed regulation.

Other Factors in Selection of Type.

In addition to these factors the question of exhaust steam for heating feed water must be considered.

If a steam turbine is used the speed can be selected to suit the pump.

Certain conditions in connection with the inlet opening of the impeller and casing and the vane angles affect the speed allowable for the pump.

The most desirable shape of suction head is shown in Fig. 1, but such design requires that the suction connection be broken in order to open the pump for inspection and this is an objectionable feature. In order to provide a horizontally split casing in which the suction and discharge connections need not be disturbed when dismantling the pump, the suction head is usually designed somewhat as shown in Fig. 2. This shape is not as good as Fig. 1 for the reason that the water entering the upper part of the impeller inlet must travel through a much more tortuous passage than is required to enter the lower part of the suction inlet. Hence such a suction head casting requires a higher suction pressure of water for the same operating conditions than is necessary with Fig. 1.

Theory of Centrifugal Flow.

It should be noted that the impeller does not exert a force which draws the water into the pump. It can simply *discharge* the water after it is received into the "eye" of the impeller and picked up by the vanes. The passing of the water from the "eye" of the impeller to the periphery by reason of the rotation leaves a space for more water to enter the "eye," and some force outside the pump must cause the rate of flow into the "eye" necessary to maintain the specified capacity.

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The only available forces we have to produce this rate of flow into the "eye" of the impeller are the atmospheric pressure and the static suction head, minus the loss due to pipe friction between the heater and the pump.

The pressure at the inlet opening to the first impeller must be slightly above the pressure at which the heated water will vaporize. The temperature of the water usually is about at the boiling point; consequently we should have not less than atmospheric pressure at the inlet to the first impeller. To bring this about the inlet to the pump must not be so small that some of the atmospheric pressure will be required to cause the water to enter the pump inlet opening at the rated quantity. Therefore only the actual gauge pressure at the pump inlet is the force upon which we can depend to cause the water to enter the inlet opening or "eye", of the impeller.

To determine the size opening necessary to permit the pump with a suction head casting as in Fig. 1 we can use formula $A = \frac{Q}{.90v}$, in which

A = area of opening in sq. ft.
Q = cu. ft. of water to enter per sec.
V = mean velocity in ft. per sec. at suction opening.

The value of V may be determined from fomula $V = \sqrt{2gh}$, using for "h" the actual suction head in ft. of water measured at the suction inlet when the water is entering this opening at a rate of flow equivalent to Q. The formula for size of opening then may be written

$$A = \frac{Q}{.90\sqrt{2gh}} \text{ or}$$

$$A = \frac{Q}{7.227\sqrt{h}}$$

or to determine the diameter of the opening in inches and using Qm in terms of gallons per minute the formula would be

$$d = \frac{144\,Qm}{7.227 \times .7854 \times 60 \times 7.48\sqrt{h}}$$

$$d = \frac{.0563\,Qm}{\sqrt{h}} \qquad \text{(Formula No. 1)}$$

For suction head as in Fig. 2 the same principle is involved, but the co-efficient instead of being .90 would be less, depending upon the proportions of the upper part of the suction head above the center line of the shaft and the directness with which the lower part leads into the inlet opening of the impeller. For a safe average the co-efficient should be .40.

Pump Openings Larger Than Theoretical.

The above represents the minimum diameter safely allowable, but in order to adhere to standard pipe sizes and use standard patterns, the pump openings actually are sometimes a little larger.

The free area, or in other words, the area of the opening into the "eye" of the impeller must be at least the same as the area of "d" in formula No. 1. Using this area as a basis, we may determine the velocity of the water entering the impeller in relation to the area at this point by formula No. 2; viz: $v = \frac{Qm}{3.12a}$ in which

v = velocity in ft. per sec.
Qm = gallons flowing per min.
a = area of impeller inlet opening.

For convenience in demonstrating the effect of capacity on speed, we will assume that the water enters the impeller equally all around the inlet opening and flows into the impeller in a radical direction. Then we may determine the proper angle of the vanes at the inlet by the simple solution of a triangle in which we know the value of the side opposite the angle is "v" as in formula No. 2 and the side adjacent is the velocity in ft. per second of the vane tip at its beginning. This may be expressed by formula No 3; viz:

$$\text{tang}\,\alpha = \frac{V}{v} \text{ in which}$$

α = angle of vane at inlet.
v = velocity of water entering impeller as per
V = velocity in ft. per sec. of vane tip at inlet.

To obtain the value of V in formula No. 3 we may use $V = .004363\,d'N$ in which

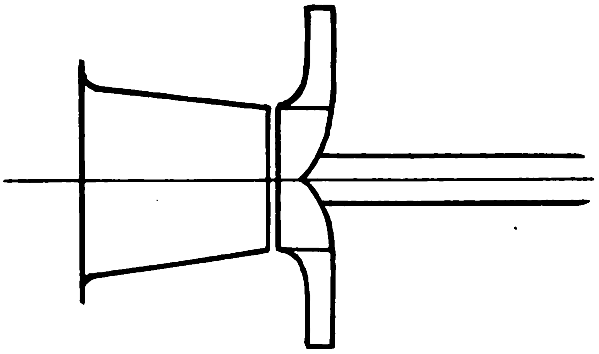

Fig. 1

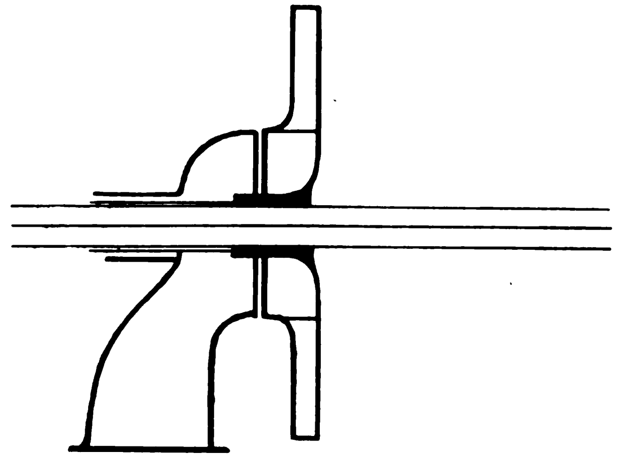

Fig. 2

Fig. 1—Shows a very desirable shape of suction head. It posesses the objectionable feature of necessitating breaking connections for inspection.

Fig. 2—Shows the shape of suction head usually used. It overcomes the objection inherent in Fig. 1.

d' = diameter at inlet tips of vanes
N = revolutions per minute

The value of d′ is partly dependent upon the general design of the pump. It may be expressed

$$d' = \sqrt{\frac{nH + a}{.7854}} \quad \text{in which}$$

H = dia. in inches across hub of impeller at inlet opening
a = area of impeller inlet opening

Qualifying Factors.

The foregoing are not formulas exactly as used by designers, because they do not take into consideration some important qualifying features. In the first place the water will not enter the impeller equally all around the inlet opening with a suction head casting as in Fig. 2 and it will not enter in a radical direction with either type of suction head, unless some stationary vanes are used in the suction head, extending into the inlet opening of the impeller and close to the inlet tips of the vanes. Such stationary vanes complicate the construction of the pump and may cause damage if pieces of wood or other solid matter is carried into the impeller with the water.

The formulas, however, show the effect of various factors on the pump design. For example they show that a high value for "V" produces a small inlet angle, (which chokes the impeller inlet and prevents obtaining full capacity), unless "v" in Formula No. 3 is also high. This latter term is affected by the capacity to be handled, which is a fixed quantity, and also by "d" in formula No. 1. The term "d" in turn is affected by the suction head on the pump. Thus we find that size of pump opening, suction pressure head, speed and temperature of water all must be taken into consideration in determining the proper boiler feed pump for a given service.

Determination of Stages.

To determine the number of stages to be used we are limited by the available speed, the desired shape of the characteristic curve, the desired efficiency and the standard line of patterns available for pump casing.

To avoid carrying a multiplicity of patterns which would make the cost of production prohibitive, the designer lays out a standard line of pump casings with openings to suit standard pipe sizes and capable of accommodating certain maximum and minimum impeller diameters. This governs to a certain extent the rotative speed and number of stages to be used for a definite head capacity.

The number of stages to be used also is dependent upon the efficiency to be obtained. Within certain limits, the efficiency is increased by increasing the number of stages.

To obtain the desired pressure at the pump discharge opening the absolute velocity of the water when leaving the impeller must be sufficient to be converted into a pressure or head in feet equivalent to that to be produced by the pump. Vanes curving backward from the direction of rotation produce the best efficiencies, and with such vanes it is possible to obtain the necessary velocity by making the outside diameter of the impeller in accordance with $v = \sqrt{2gh}$, in which

v = velocity in ft. per sec.
h = head in ft. to be overcome
g = force of gravity.

The rim speed or peripheral velocity of the impeller in ft. per minute is equal to

$$\frac{dn\,N}{12} \quad \text{in which}$$

d = outside dia in inches
N = R.P.M.

Then

$$\frac{dn\,N}{12} = 60\sqrt{2gh} \quad \text{or}$$

$$.262\,dN = 482.4\sqrt{h}$$

$$d = \frac{482.4\sqrt{h}}{.262\,N}$$

$$d = \frac{1840\sqrt{h}}{N}$$

With the discharge from the pump completely closed the total pressure developed will be slightly less than $h = \frac{V^2}{2g}$. This is commonly called the "shutoff pressure." Boiler feed pumps seldom, if ever, are started up against a pressure lower than the normal working head. Consequently, if the outside diameter of the impeller is made in accordance with $v = \sqrt{2gh}$ where "h" equals the working head, the impeller can deliver the rated quantity against the head "h" but the shut-off pressure will be slightly less than the working head and there will be no excess pressure available to start the flow; hence the pump can not be put into service. For this reason, and also in order to obtain a characteristic curve with the pressure gradually dropping as the capacity delivered is increased, which makes a more stable pump, the outside diameter is usually calculated in accordance with $v = \sqrt{2gh}$ where "h" is about 15 per cent to 20 per cent higher than the actual working head at rated capacity.

Variable Speed a Necessity.

Boiler feed pumps usually operate under conditions requiring a variable capacity, but with practically a uniform working pressure. To meet this condition efficiently it is necessary to vary the speed of the pump, and in order that these speed variations be as small as possible for the desired variation in capacity, the characteristic curve should be as nearly a straight horizontal line as possible. To obtain a perfectly horizontal straight line is impossible, for with practically all impellers there is at least a slight rise in pressure with an increase in quantity delivered between zero and the rated quantity.

The pressure obtainable per stage is limited only by the peripheral velocity at the outlet tips of the vanes, assuming, of course, that the requisite number of vanes is used in the impeller. It has been shown, however, that the allowable speed is affected by the capacity to be pumped and the maximum impeller diameter is limited by the standard line of patterns already referred to. Also the diameter of the impeller and the rotative speed must be such that it will be possible to put enough vanes into the impeller of such length that they will overlap one another when laid out according to the correct inlet and outlet angles. We may find a condition where the maximum allowable rotative speed for capacity and size of suction inlet will be so high that when the outside diameter is calculated in accordance with rules already given it will be smaller than the inlet diameter. The rotative speed must be selected so that the outside diameter of the impeller will be enough larger than the inlet diameter to give vanes of such length that they can efficiently impart the necessary velocity to the water.

In small capacities it would often be quite feasible to use a single stage pump for the usual boiler feed pressures, but to obtain this result the speeds usually must range between 4,000 and 6,000 rpm. which does not often work out successfully in American installations. In this country the most successful centrifugal boiler feed pumps run at speeds of 3,600 rpm. and less and these pumps usually have three or more stages. Such a combination of speed and number of stages gives the most desirable efficiencies and produces a pump of reasonable cost and dimensions.

Governors.

For the automatic regulation of capacity and pressure of turbine driven boiler feed pumps a constant excess pressure governor is usually the most desirable. The simplest form of such a governor is a double seated, semi-balanced poppet valve installed in the steam line to the turbine and controlled by a diaphragm on top of which the feed line pressure is directed and the steam pressure acts under the diaphragm. The excess pressure is regulated by a weight mounted on a lever fastened to the stem which connects the poppet valve to the diaphragm. By means of the excess pressure governor the feed line pressure always is maintained at the excess amount necessary to feed the boilers and if the boiler pressure rises or falls the feed line pressure rises and falls to the same extent. The excess pressure governor consequently always will prevent too high or too low a feed line pressure for the boiler pressure. With a constant pressure governor, and a variable boiler pressure the feed line pressure at times is higher than necessary and at other times may be less than required, which necessitates frequent adjustment of the governor by the operator.

New Method of Determining Heat Losses Due to Incomplete Combustion in Furnaces

By O. I. HOUSEY

As a continuation of my previous article under the same heading which appeared in the August issue, Mr. K. E. Nielsen has made a line of experiments in order to prove the exactness of my method. A detailed report of these extensive experiments will form the last part of this article.

Although the experiments made in order to check the exactness of the new method were quite satisfactory, the application of the Orsat Apparatus for analysis in the laboratory gave results which were altogether misleading. A thorough investigation of this fact showed that the errors were mainly due to variations in the atmospheric temperature. This lack in exactness, however, does not refer in particular to this method alone, but is a general weakness of the Orsat Apparatus which affects the old methods just as much.

After a long line of experiments we decided upon an apparatus as shown in Fig. 1. The graduated measuring burette and the absorption pipettes are the same as in the ordinary Orsat Apparatus, but the measuring burette and the water jacket F, are provided with an air jacket E placed inside the water jacket. This air jacket carries a gage tube H. In E is a small amount of distilled water for the purpose of keeping the air 100 per cent saturated. J is a cock which should be kept closed during the analysis, the purpose of this cock is only to enable the operator to equalize the inside pressures and thus keep the pressure head, for which a correction is necessary, as small as possible when working under variations in atmospheric pressure and temperature. The particular shape of the two jackets is to provide equal conditions for the enclosed volumes. In the ordinary Orsat the water jacket is cylindrically shaped, and in this fact lies one source of error, because about one-half of the volume of the measuring burette is taken up by the bulb at the top, and this part of it is less effectively protected due to the smaller volume of water at this point. This fact will be noticed in Fig. 2.

The manipulation of this corrected apparatus differs from that of the ordinary Orsat in the following way. When the gas sample has been drawn into the graduated measuring burette the levelling bottle is manipulated up and down until the meniscus in both branches of the U tube gage stands even; the cock K is then closed and the volume is registered. This method, of course, will give an initial reading different from zero, a fact, which is not of any great inconvenience, but will only require an additional correction of the observed volumes. Apart from this the ordinary procedure, as previously described, is followed. During the performance of the analysis it should be remembered that the stopper L must be closed before the sample is drawn over into any of the absorption pipettes, and when the sample is drawn back into the measuring burette the stopper is opened and the reading of the volume should not take place until the gage tube indicates even pressures on either sides.

In order to avoid the above mentioned correction of the initial reading of the volume, the stopper J could be left open for a short moment after having drawn in 100 cc. of a sample.

Tests Made to Compare Methods.

Table I shows the results of a number of analyses made in a laboratory where an Orsat apparatus as the one described above was employed, and for comparison a second person worked in the same laboratory and simultaneously with the first mentioned made a number of analyses by means of an Orsat apparatus without the

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correction tube. These analyses were made on gas mixtures of known constituents.

Table II contains a number of analyses performed under the conditions in an ordinary boiler room, these analyses were made in order to emphasize the importance of being able to perform the analysis right in the spot under the prevailing conditions.

Experiments Which Check Test Results.

Being aware of the great lack in exactness in the previously applied method it is evident that an emperical check on the new method is very desirable. These experiments have been conducted by Mr. K. E. Nielsen in the laboratories of The Danish Society for Investigation on Fuels and Combustion (Dansk Braendsels og Kontrolforening), and the following constitute an extract of Mr. Nielsen's report.

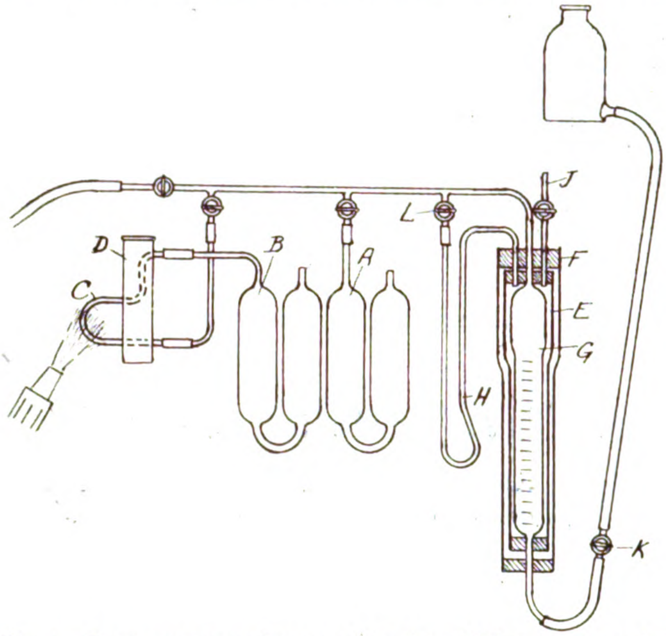

Fig. 1—Orsat apparatus improved by the addition of air cooled measuring burette and water jacket.

It has been pointed out that the main source of errors could be found in applying the volumetric analytical method, but this is not all of them. In selecting the proper apparatus by which to check the new method, we found the ordinary Orsat apparatus with from 3 to 5 pipettes quite unsatisfactory. Among the numerous reagents applied as absorbents of gas constituents the solution of potassium hydroxide actually is the only one which is satisfactory both in regard to speed, reliability and absorption power; whereas the absorption of Oxygen and Carbon-monoxide eventually followed by a combustion (or explosion) of Methane and Hydrogen is practically impossible to perform with any satisfactory exactness even when used in a laboratory where the conditions are the best obtainable, and the absorbents can be renewed whenever desired. The ordinary Orsat may be used for an approximate determination of the constituents of illuminating or producer gas, but the sources of error are so numerous and of so great consequence, that it may be deemed unpracticable for any determination of constituents represented by small fractions. It may therefore appear evident that the ordinary method of direct volumetric analysis as used on flue gases could not be used as a check on the new method, as it is liable to give larger errors than the method we wish to prove the exactness of.

It is, however, possible to make a reliable weight analysis of flue gas, but this method is very intricate and requires a large amount of gas of uniform mixture, which again is difficult to store. Our experience has been that the best way is to produce a gas mixture of known constituents, and to analyze this gas mixture by means of the new method. Ordinary illuminating gas rarefied with air or nitrogen and eventually mixed with a small amount of carbon monoxide has proved to serve this end very satisfactory and to be close enough in likeness to flue gas.

Known Gas Mixtures Employed.

We decided to use the following procedure. Two gas mixtures were produced slightly differing in their constituents; these mixtures were produced so rich in their constituents as to allow an analysis according to known methods, without exceeding the limits for errors which could logically be tolerated. These gases were mixed with air of low oxygen content to such an extent that the constituted mixture had a fair resemblance to flue gas from a coal fire. The heat values of these mixtures were then determined by the new method and compared with the heating value determined exactly. In the determination of the heating value by means of the new method two different apparatus were applied; one of them being of high grade in exactness the other being the improved Orsat as described in this and the previous article. Besides the work on the producer gas mixtures we made a number of analyses with actual flue gas samples.

According to the above mentioned the first step in the procedure to product and next to analyze a gas mixture of rich combustible gases. The illuminating gas was taken right from the city supply line. Approximately 11 tr. of illuminating gas was drawn through water into a special gasometer, where the gas only has contact with mercury and glass, in this way we have been able to store gases for any length of time without any noticeable changing of their constituents. During the following analysis a Hempel gas burette with attachment for temperature and pressure corrections was used; mercury being used for displacement. This burette was used together with an ordinary outfit of Hempel gas absorption pipettes. The gas burette is shown in Fig. 3. where A is the metering tube, B the correction tube and C the gage tube. D is a glass vessel filled with water at the inside of which A and B are placed besides a stirrer. Carbon-dioxide, Heavy Hydrocarbons and Oxygen were absorbed in respectively, Potassium Hydroxide, Fuming Sulphuric acid and Phosphrous, whereas Carbon-monoxide, Hydrogen and Methane were determined (after adding Air) through explosion in an explosion pipette over mercury followed by a determination of the contraction (c), the amount of Co_2 formed (co_2) and the remnant

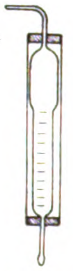

Fig. 2—Improved design of measuring burette which equalizes errors due to variations in volume of water.

TABLE I

	Orsat With the Correction Tube				Orsat Without the Correction Tube			
	CO₂ %	c %	co₂ %	Heat Loss Calculated By Analysis Btu./Cu. Ft.	CO₂ %	c %	co₂ %	Heat Loss Calculated By Analysis Btu./Cu. Ft.
I	1.8	3.8	2.8	16.8	1.4	2.8	2.7	13.9
II	2.1	3.6	3.1	16.8	2.2	4.0	3.1	18.0
III	1.4	3.7	1.7	14.4	1.4	2.5	1.1	9.6
IV	12.2	2.3	2.5	11.8	12.4	2.2	2.2	10.9
V					1.7	1.8	.2	5.8
					2.7	.5	.3	2.1

TABLE II

	CO₂	c	co₂	Heat Loss Gassy Fuels† Btu./Cu. Ft.	Heat Loss Coke* Btu /Cu. F'.	Heat Loss in Percentage of Fuel		
						Through Unburnt Gases	Through Dry Smoke	Total
Coke	10.0	4.9	6.6		25.7	30.3	8.4	38.7
Coke	12.5	.6	1.1		3.8	5.4	9.2	14.6
Coke	6.6	1.8	1.8		7.8	18.4	14.8	33.2
Coal	8.5	.7	.7	3.4		6.9	24.0	30.9
Ccal	12.8	1.2	1.1	5.7		7.3	19.7	27.0
Coal	12.3	2.3	2.4	11.6		13.7	8.5	22.2

†The heat losses for gassy fuels is calculated by formula (5) in the previous article: $w=3.01\ c+1.91\ co_2$.

*The heat losses for coke is calculated by formula (4) $(CH_4=O)$, $w=1.93\ c+2.45\ co_2$.

TABLE III

Percentage Content of	CO₂	CₘHₙ	O₂	CO	H₂	CH₄	N₂ (by diff.)
Gas Mixture A......	2.5	1.9	7.6	7.5	26.6	15.4	38.5
Gas Mixture B......	2.3	.9	11.6	27.1	8 7	5.3	44.1

TABLE IV

	C	CO₂	Heat Value Expressed in Btu Per Cu. Ft.	
			Calculated by formula (5)	Calculated from the analysis (Table III)
Gas Mixture A	78.24	28.7	291.2	290.8
Gas Mixture B	39.09	35.1	185.3	188.0

Oxygen. We were then able to determine these constituents by means of the following equations:

$$c = \frac{1}{2} Co + \frac{3}{2} H_2 - 2\,CH_4,$$

$$co_2 = CO + CH_4,$$

$$O_2 = \tfrac{1}{2}\,CO + \tfrac{1}{2}\,H_2 - 2\,CH_4,$$

The first two of these equations are identical to (1) and (2) in the previous article, the last equation is based on the determination of the amount of Oxygen used. Excepting what has now been described all other details in connection with the actual procedure should not be mentioned in this article.

One gas mixture being produced as described above still another mixture was produced with a larger content of Co; this was done in regard to the fact that the overwhelming part of the combustible gases in flue gas is CO, whereas Hydrogen and Methane are of comparatively less importance. The Carbon-monoxide for this purpose was produced by heating Oxalatic acid with concentrated sulphuric acid and washing with caustic potash in order to remove the Carbonic acid. The CO gases in this way being cleaned were collected over water, were mixed with illuminating gas and air and drawn over into the previously mentioned mercury gasometer. This gas mixture too was analysed as described. In the following tabulation the two gas mixtures are called A and B and obtained results are listed according to the headings.

The results entered in table III are averages of three analyses for each gas mixture, the largest errors were + or — .1 per cent of the average for the three first constituents and + or — .3 to .4 per cent for the three last, which is as good as could be expected as the graduation on the measuring tube will not allow for closer observation than .05 to .1 cc. and the error will necessary be larger for these constituents determined after combustion because only 15 to 25 per cent of the residual sample is used in order to allow for enough air to be drawn in as is necessary for a perfect combustion. There was a satisfactory harmony between results obtained through explosion and those obtained through combustion in a slow combustion capillary tube. The obtained exactness was sufficient and the consequence of the small errors was diminished, of course, when the gas mixtures, strongly diluted, were used in the following experiments.

Calculations Resulting From Tests.

We are now in position to calculate the heat value of the gas mixtures A and B except for the construction of the heavy hydrocarbons C_mH_n, which we do not know exactly. We know, however, that the heavy hydrocarbons in illuminating gas mainly are constituted by overwhelming Ethylen and some Benzol, and we feel entitled to assume that unburnt flue gases from a coal fire undoubtedly contains the very same constituents, in about the same proportions. Hence we make the assumption that the C_mH_n is constituted by ¾ Ethylen and ¼ Benzol.

The combustion of these constituents take place according to the following reactions:

For Ethylen: $C_2H_4 + 3\,O_2 = 2\,CO_2 -- 2\,H_2O$, indicating that one volume of C_2H_4 burns with a contraction of two volumes andproduces two volumes of CO_2.

For Benzol: $2\,C_6H_6 + 15\,O_2 = 12\,CO_2 - 6\,H_2O$; indicating that one vol. of C_6H_6 burns with a contraction of 2½ volumes and produces 6 volumes of CO_2.

The total contraction of the mentioned mixture of ¾ C_2H_4 and ¼ C_6H_6 is hereafter:

$c = ¾\,2 + ¼\,2.5 = 2.12$, and the total amount of CO_2: $co_2 = ¾\,2 + ¼\,6 = 3.0$.

Knowing that the heat value per cu. ft. (32°F., 30″ merc.) of Ethylen is 1;585 Btu. and of Benzol 3,750 Btu., the heat value of air containing 1 per cent of the Ethylen-Benzol gas mixture is:

$w = ¾\,15.85 + ¼\,37.50 = 21.37$ Btu.

Calculating the heat value by means of the formula (5) developed in the previous article, we find:

$w = 3.01\,c + 1.91\,co_2$;

$w = 3.01\,2.12 \div 1.91\,3.0 = 12.1$ Btu.

which shows an apparent lack in harmony between the two equations, the latter giving about 43 per cent lower values than the former. But we could not expect it to be otherwise, because the formula developed in the previous article was exclusively developed for gases constituted by CO, H_2 and CH_4. In spite of this great lack in exactness we are yet justified in applying formula (5) in case of extremely lean gas mixtures as flue gas, where CmHn only presents small fractions, because any determination derived at through an ordinary absorption analysis of CmHn is liable to give far larger errors. Hence CmHn is burned in the capillary tube together with CO, H_2 and CH_4.

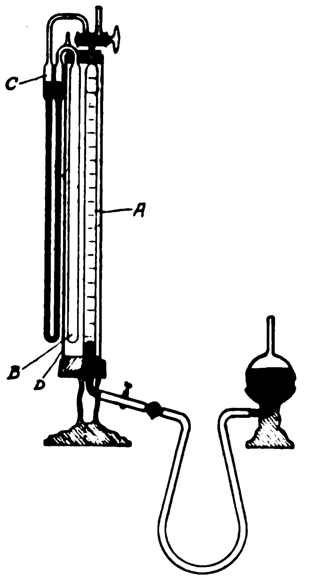

Fig. 3—A metering burette designed for measuring displacement in the absorption pipettes.

The calculated available heat values are entered in table IV, the heat values for CO, H_2 and CH_4 being those given in the previous article.

In this table there will be noticed a very satisfactory harmony between the heat values calculated by formula (5) and the ones obtained through the analysis.

Having now acquired two produced gas mixtures of as closely known constituents as obtainable, and having determined the heat values of these two mixtures in two different ways, we have now reached the point in our procedure where we want to analyze and determine the heat values of these mixtures highly rarefied through atmospheric air. This analysis we will perform with the largest obtainable exactness in a suitable apparatus besides using the improved Orsat described in the previous and in this article.

Lean Gas.

In the burette A shown in Fig. 3, a certain volume of the concentrated gas mixtures was metered, and was then transferred to the gasometer; and in the same way a 10 to 20 times as large volume of air of low oxygen content was metered and transferred to the gasometer and mixed with the concentrated mixtures. Two such rarefied gas mixtures were produced and are in the following called Ar and Br, table V will give the exact constituents, gas mixture A being rarefied with air in the proportion 1 : 19.35 and B in the proportion 1 :10.94. The values for c and co_2 is calculated from the reactions.

Besides those constituents listed in the table the mixtures contained a slight amount of carbon dioxide, approximately 10 per cent oxygen and approximately 85 per cent nitrogen. It will be noticed that the two mixtures resemble flue gas from a coal fire, with the exception of the contents of CO_2, which in this case is very much smaller than in case of actual flue gases, a fact which however is immaterial for the comparison, as the absorption of the CO_2 always is the first step in the volumetric analysis.

During the actual performance of the analysis the same metering burette (Fig. 3), was used and mercury was used for displacement even in the absorption pipettes. The absorption of CO_2 was done in a pipette where the absorbent, 3-5 cc. of caustic potash, was placed on top of the mercury. The application of mercury instead of water reduces the errors due to absorption and temperature variations materially.

Table VI contains the results obtained by three analyses of each mixture. The table shows a good harmony between the observed and the calculated values for c and co_2 and consequently a good harmony between the estimated and observed heat values. The errors are all within the limits for probable errors in observations, which is considered + or — .1 cc. Making a similar estimate as the one made in the previous article the most unfavorable conditions will result from dc = + or — .1, and dco_2 = O, and as a consequence of this the maximum error will be:

$\triangle w_{max.} = 3.02\,(+1) = -- .3$ (Btu.), and it will be seen that this tolerance is in very close harmony with the results in table VI.

We are now justified in making the conclusion that the reactions and combustions taking place in this method of analysis are just as perfect as in the case of an analysis on actual flue gases. There may, of course, be instances where the constituents of combustible gases are different from those used in this case or they may be present in very much different percentages, but as far as our experience goes, using ordinary fuel, the flue gases obtained will differ but little from the mixtures examined and described in this article.

TABLE V

	C_mH_n %	CO %	H_2 %	CH_4 %	c	co_2	HEAT VALUE IN BTU., PER CU. FT.	
							By Formula (5)	From Analysis
Gas Mixture A_r	.10	.39	1.37	. 0	4.04	1.48	15.06	15.06
Gas Mixture B_r	.08	2.49	.80	.48	3.57	3.21	16.97	17.20

TABLE VI

	Metered Gas Sample cc	RESULTS OBTAINED BY THE PERFORMED ANALYSIS			RESULTS CALCULATED BY THE ANALYSIS GIVEN IN TABLE V		
		c	co_2	Heat Value Btu./Cu. Ft.	c	co_2	Heat Value Btu./Cu. Ft.
Gas Mixture A_r	85.6 94.05 100.2	3.4 3.8 4.1	1.35 1.45 1.55	15.05 15.18 15.40	3.46 3.80 4.05	1.27 1.39 1.48	15.05
Gas Mixture B_r	98.7 86.5 96.8	3.55 3.0 3.45	3.15 2.85 3.10	16.98 16.76 16.98	3.52 3.09 3.46	3.17 2.78 3.11	16.98

TABLE VII

Metered cc. of Sample	OBSERVED		Heat Value Btu/cu. ft.
	C	CO_2	
100	2.30	2.35	11.5
95.95	2.25	2.35	11.8
99	2.25	2.40	11.5
		Average	11.6

Tests of Unknown Mixtures.

Table VII shows an analysis of a flue gas sample taken on a coal burning furnace in a domestic heating boiler. The sample contained 12.3 per cent CO_2.

Even in this case the three analyses show good harmony.

The apparatus described in this article is very well suited for an exact determination of the losses due to unburnt gases in flue gas. Having acquired the necessary practice the determination of the heat loss for a certain sample can be performed within 15 minutes.

Besides the work which has now being recorded, and by which the method as such has been proven, a number of analyses were made using the improved Orsat, which has been described in this and the previous article. Analyses were made on the same gas mixtures Ar and Br.

TABLE VIII

	Metered cc. of Sample	OBSERVATIONS OF			CALCULATIONS BY TABLE V		
		c	co_2	Heat Value Btu./Cu. Ft.	c	co_2	Heat Value Btu./Cu. Ft.
Gas Mixture Ar	97.4 96.2 98.2	3.9 3.8 4.0	1.3 1.3 1.3	14.6 14.5 14.7	3.94 3.89 3.97	1.44 1.42 1.45	15.0
Gas Mixture B_r	99.4 100.0 97.6	3.6 3.8 3.6	2.8 2.8 3.0	16.3 16.8 17.0	3.55 3.57 3.48	3.19 3.21 3.13	16.9

A comparison of the results obtained with the original apparatus with those given in table V and VI showed the unreliability of this apparatus. In some instances the results were in perfect harmony with the exact calculations, but just as often, even when the utmost care was exercised, the analysis gave results amounting to only 25 or 20 per cent of the calculated values. The exactness of the actual method having now been proven the errors could only originate from imperfections of the applied apparatus. The large errors originated mainly from two distinct sources: 1) Absorption of gases in the displacing water in burette and pipettes, and 2) Variations in the atmospheric temperature. Experiments showed that the first mentioned source only is of minor consequence. The apparatus used to prove this fact was made up of the Orsat apparatus combined with the exact measuring tube (A) and we found that the readings were exact even if new absorbents were used. Hence the overwhelming part of the errors must be due to the variations in the atmospheric temperature, and this has been sufficiently proven through the long line of experiments made. Performing the analysis in a cold room (54 to 57°F.) gave results rather low, even if the apparatus had been given sufficiently long time to adapt the room temperature. The only explanation of this fact is that the radiated and conducted heat from the operators body is transferred to the gases and causes them to expand. Making the analysis in a warmer room the effect of the heat from the body will be eliminated, but even in this case other temperature influences may be felt, for instance, radiated heat or a cold draft, and it is, of course, impossible to make any estimate of the extent to which these circumstances have affected the result.

As a result of these experiments it should be stated that a water jacket as the one ordinarily used with the Orsat apparatus is quite insufficient as a protection against variations in temperature.

TABLE IX

Content of CO_2: 12.3%

Metered cc. of Sample	Observations of: C	Observations of: CO_2	Heat Value Btu cu. ft.
100	2.5	2.4	12.12
87.2	2.0	2.0	11.33
100	2.3	2.3	11.68
		Average:	11.71

In order to obtain satisfactory results in the application of the method described in these articles it must be regarded as imperative to use the correction for temperature variations even in the apparatus designed for work outside the laboratory. The temperature correction device attached to this apparatus is based on the "Peterson" compensation principle, but we have succeeded in giving the apparatus one for outside work more suitable shape, and it works with an exactness large enough for all practical conditions without delaying or complicating the work to any noticeable extent. Having obtained the necessary practice an analysis with this apparatus could be performed within seven minutes.

Besides the analyses recorded in table VIII ,several analyses on the previously mentioned gas sample were made using the improved Orsat, these analyses are recorded in table IX.

It will be noticed that the inexactness here is slightly larger than for the apparatus using exclusively mercury for displacement, and we must in this case content ourselves with an allowance of + or — .2 cc.

According to the experiments which these articles have dealt with we feel justified in stating that the method described in these articles is a quick, reliable and exact means of determining the heat losses in flue gases due to incomplete combustion. The experiments have proven that the application of an apparatus with mercury displacement for work in laboratories is particularly serviceable for great exactness and good harmony, and even the portable apparatus fitted with the temperature correction gives very satisfactory results. It should in particular be emphasized that the new method is well suited for use right in the boiler room, and makes possible the determination of the heat losses within but a few minutes, where the older methods were slow, and only furnished results, which were often practically worthless.

WESTINGHOUSE BRINGS OUT NEW TRANSFORMER INVENTION

Sargent & Lundy, consulting engineers, of Chicago, representing the Middle West Power Company, have purchased from the Westinghouse Electric & Manufacturing Company, a 25,000 kva. bank of power transformer design, claimed to eliminate any possibility of the explosions which sometimes occur in large transformers. These transformers are to be installed in the Grand Tower Illinois Station of the Middle West Power Company.

This new Westinghouse principle consists of filling the transformer case above the oil level with nitrogen, which is a harmless and inert gas that is incapable of forming an explosive mixture with oil vapors arising from the oil. The nitrogen gas used is generated in an ingenious device of simple design which is attached directly to the transformer tank. This generator works automatically to keep the space above the oil level always full of the protective nitrogen. No oxygen, which is the element needed to produce explositions or start a fire, can enter or be present in the tank. A big feature of the new invention is that this protective layer of inert gas above the oil level acts as a cushion or buffer to take the shock of any sudden pressures that develop under the oil level if there should be a short circuit or any defect in the transformer windings. An electric arc under the oil level, if it should occur, can produce a tremendously quick pressure in a tank. The sudden impact of this pressure against the walls and cover of a transformer tank which is completely full of oil, has been known to burst the tank and cause a serious interruption of service to electric power and light users. This cushion of nitrogen gas is easily compressed and it is enough of a buffer to take the brunt of the explosive pressure and save the tank from injury. The oil in the transformer repreesents quite an investment and the inert gas principle protects it against both air and moisture and claims are made that the oil with the new princible will improve with age.

OXIDIZED KEROSENES AS FUELS

The solution of still another industrial problem has been undertaken at the research laboratories of Carnegie Institute of Technology, Pittsburgh, in experiments to determine the relative efficiency of kerosenes and oxidized kerosenes as fuels.

In accordance with the policy of the Institute to link up its educational facilities with modern industry, the Department of Chemical Engineering has been conducting a series of tests to determine the relative merits of various oils as usable fuels. The completion of this important work should go a long way toward solving the problem of oil conservation, by the possible development of a new fuel.

According to a report by Dr. J. H. James, head of the department conducting the experiments, oxidized kerosenes cause less "knocking" tendencies than straight kerosene when used in a kerosene engine. The tests also showed that oxidized kerosenes have approximately the same power development as ordinary kerosene, in spite of the fact that their thermal value is one-eighth less. Dr. James attributes the efficiency of the oxidized kerosenes to the better "clean up" in the combustion of these partially oxidized fuels.

The success of the experimental work at Carnegie at this stage gives promise that oxidized kerosene, which is manufactured by catalytic oxidation from low grade petroleum, may become a useful fuel in the future. Its properties may cause it to be used industrially in kerosene engines or blended with gasoline for use in gasoline engines. Although it has a somewhat lower value than ordinary kerosene, one of the most favorable features of its effectiveness is that it undergoes much better combustion in the internal combustion engine.

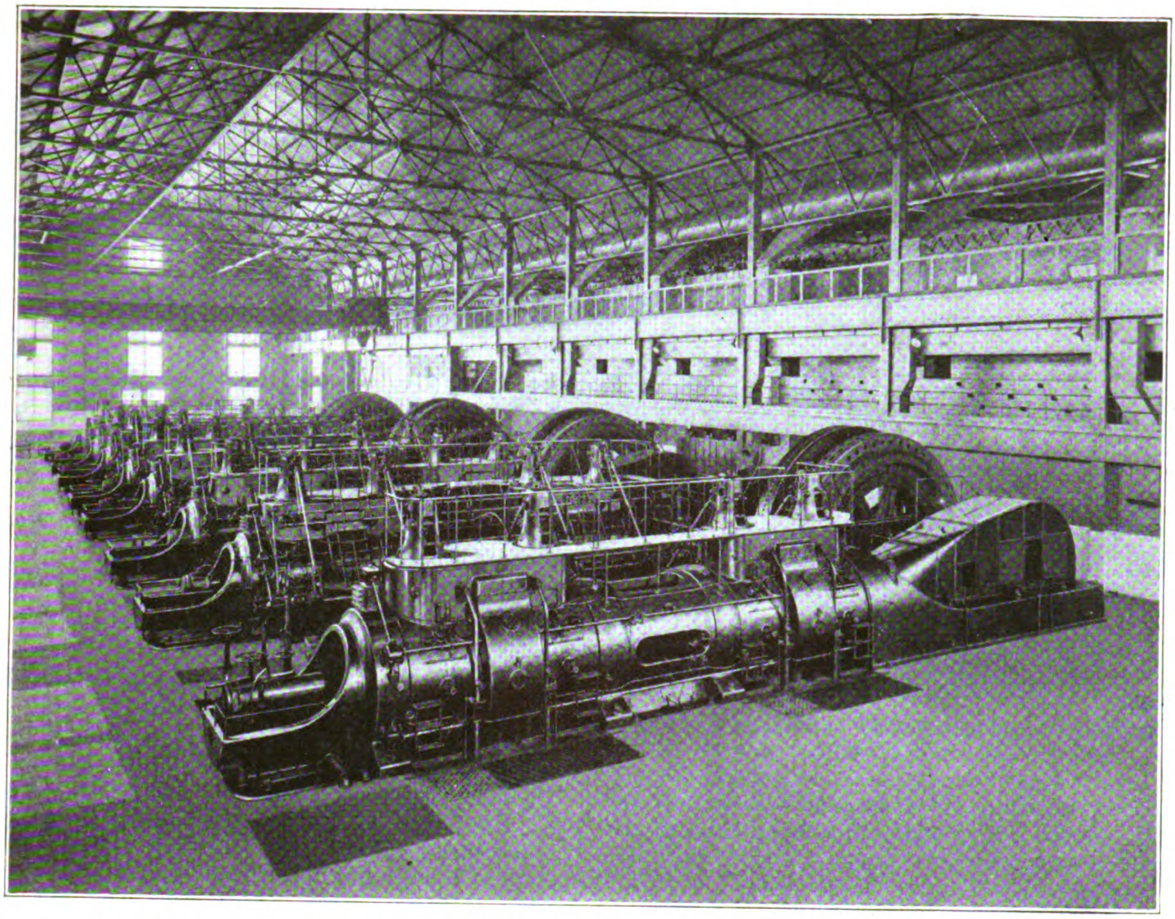

Fig. 1—Showing 5 horizontal twin tandem type blast furnace engine generator sets. These engines have four double acting cylinders 48 in. diam. by 60 in. stroke, operating at 83⅓ rpm. developing 3,500 kw.

Large Gas Engines Installed in Steel Plants

A Comparison of Btu. Recoveries by Gas-engines Versus Steam Units. Marked Advance in Valve-gear Construction Results in Unexpected Economy and Capacity in New 3500 kw. Machines.

By C. G. SPRADO*

THE large gas engine has long since passed its experimental stage and the experience of the past twenty years in Europe and America has fully demonstrated its equal reliability and greatly superior thermal efficiency to steam plants using waste gases as fuel.

Gas engines are installed in practically all of the large steel plants on the European continent, but in America their use has been confined principally to the plants of the United States Steel, Bethlehem Steel and Lackawanna Steel Companies, the latter being the first in America to employ gas engines.

That the gas engine has not been more widely adopted in American steel plants, is probably due to the lack of appreciation of the enormous savings possible by its use and the further fact that with the cheap coal formerly obtainable, managers were more interested in the steel output of their plants than in power costs.

More Excess Power From Gas Engines.

A 600 ton furnace burning 25 tons of coke per hour gives off approximately 344 million Btu. per hour in the gas and after heating the stoves and allowing for waste and miscellaneous uses, there remains approximately 200 million Btu. per hour available for blowing engines and power production. If gas blowing engines are employed, there will remain 170 million Btu. per hour for power production, which if used in gas engines having an efficiency of 24.35 per cent, will produce 12,000 kw.

If the furnace is blown by steam units there will remain approximately 125 million Btu., which if used in steam units having an overall efficiency of 12.63 per cent, (including boilers at 70 per cent) will produce 5,000 kw.

Roughly speaking, if gas blowing engines are used, 50 per cent of the heat in the gas or 27 per cent of the heat in the coke will be available for general production, or if steam blowers are used, 36 per cent of the heat in the gas or 20 per cent of the heat in the coke will remain for power production.

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The Btu. value of blast furnace gas varies according to the coke rate, ranging from 90 to 95 Btu. per cu ft. in Chicago and the middle west and from 100 to 110 Btu. in eastern and southern plants and also in Europe and these variations in heat value must be taken into account in making comparisons.

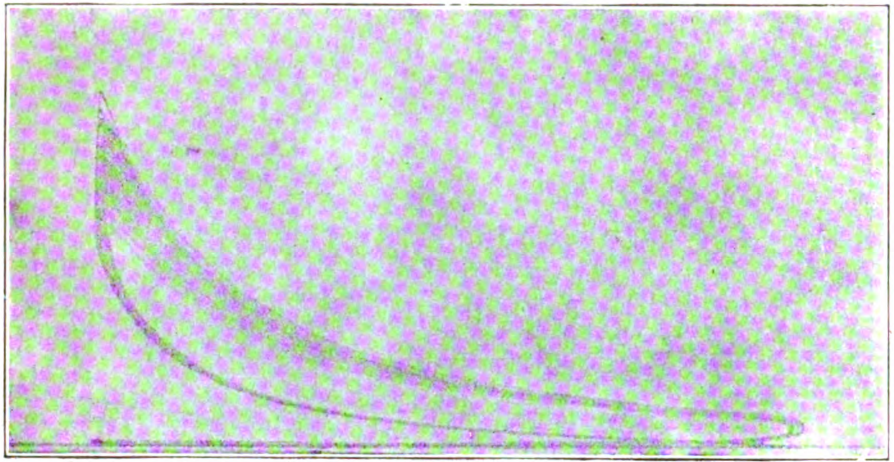

Fig. 4—Showing an indicator card taken from an engine with old style valve-gear.

Limitations of This Type Engine.

One of the limitations of the gas engine has been its lack of overload capacity to carry the "peaks" which occur periodically in nearly all plants.

The power of a gas engine is primarily dependent upon the weight of gas per charge and this may be increased in three ways: First, by increasing the volumetric efficiency through the reduction of valve and port friction and, second, by "supercharging" by means of compressors. The third method is to reduce the excess of air, thus increasing the weight of gas per charge and obtaining better combustion through a more perfect mixture.

The volumetric efficiency of an engine is practically fixed by the valve timing as well as the valve and port areas on both the inlet and exhaust and but little improvement can be looked for in this direction, as most modern gas engines have a volumetric efficiency of more than 95 per cent.

Super-charging has been tried in a number of plants in Europe, especially in Germany, with moderate success. There is no question as to the gain in power by super-charging, but this is partly offset by the power required for the charging apparatus, and there are also some mechanical complications.

In some cases it has been found that the operation of the super-charging engines is unstable on account of lack of proper control and due to the pressure used on the gas, leakage may occur, which would endanger the health of the operators and even cause explosions, and it may safely be said that at the present time "supercharging" is in the experimental stage.

Description of Latest Large Engine.

The third method of increasing the mep., that is, by the reduction of excess air, seems to offer the greatest possibilities at this time and has been very successfully applied by the Allis-Chalmers Manufacturing Company on five engines recently constructed for the United States Steel Corporation.

These engines (Fig. 1) are of the horizontal twin tandem type, having four double acting cylinders 48-in. diameter by 60-in. stroke, operating 83 1/3 rpm. The piston rods are 16 in. in diameter, hollow bored for water cooling; the crank pins are 21 in. by 19 in.; the crosshead pin 16 in. by 19 in. and the main bearings 32 in. diameter by 54 in. long, each unit weighing 1,000 tons.

Improved Valve Gear.

The valve gear operates on the stratification system, varying the amount of gas per charge and also partly on the throttling system, combining the two methods so that the amount of the charge is reduced at light loads in such a way as to secure a very intimate mixture of the gas and air entering the cylinder.

Fig. No. 4 is an indicator card from an engine having the old style valve gear and Fig. No. 5 from an engine with the new mixing valve gear, from which it will be seen that the burning line has been so changed that the cards are very much "fatter," thus giving a higher mep. with the same or even lower initial explosion pressure than with the older type of valve gear.

It has also been found that with the new valve gear the engines will operate through a wide Btu. variation in the gas without the necessity of making any adjustments, either in the mixture or ignition setting.

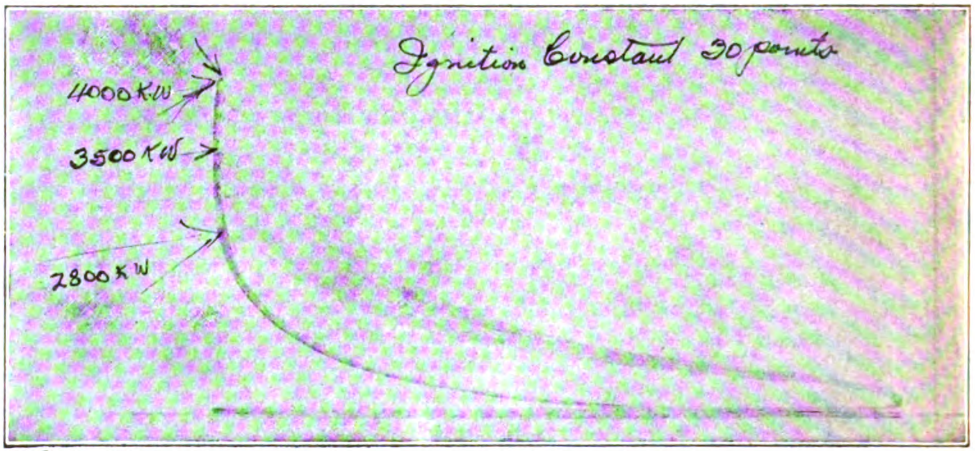

Fig. 5—Showing the changed burning line resulting from change to new mixing valve-gear.

Performance Above Expectations.

These engines were very conservatively rated at 3,300 kw. normal and 3,630 kw. maximum load with 92 Btu. gas, but due to the improved valve gear, it has been found in practice that they will readily carry continuous loads up to 4,000 kw. and peak loads above 4,300 kw., thus indicating an increased capacity of 20 per cent to

25 per cent over engines using the older type of valve gear.

Not only is the capacity increased, but due to the better mixture, the economy is improved as shown by figures obtained in the regular operation which indicate a consumption of 12,640 Btu. per kw. hour with a load of 3,600 kw. and 13,300 Btu. per kw hour at 3,300 kw. load.

With the present high fuel costs, the economical utilization of waste gases is an important factor in the cost of steel and if a cubic foot of gas burned in a gas engine cylinder will produce twice as much power as the same quantity of gas burned under a boiler, ("Hermanns" gives the ratio as 15:32) gas engines will eventually be adopted by the majority of large steel plants.

Judging the Combustion of Liquid Fuels

Formula for Calculating the Results of Combustion from the Waste Gas Analysis Applied to Liquid Fuels—By-Product Tar Used as a Typical Example—Moisture Calculation Not Essential.

By A. G. WITTING*

IN the October, 1922, issue of the Blast Furnace and Steel Plant the writer presented a formula by means of which the combustion of a gaseous fuel could be judged from a set of analyses, the fuel gas analysis being directly translated into the waste gas analysis. In the paper, mention was made of the fact that the formula could as well be applied to liquid fuels. Having received requests for further explanation of this point the writer submits herewith a modification of the formula applicable to liquid fuels.

A liquid fuel, being a combination of various hydrocarbon compounds, consists as a rule only of two combustible constituents, hydrogen and carbon, although certain fuel oils in addition contain small amounts of oxygen, nitrogen and sulphur. The fuel is generally atomized in the combustion chamber by means of steam and becomes dissociated into its elementary components after which it burns, the carbon first to CO which, with sufficient air supply, is further oxidized to CO_2. During one phase or other of the combustion process the fuel changes from a liquid to a gaseous state, and it is on the probably incorrect assumption that the gasification takes place before the oxidation, that the calculations are based. It is, however, to be noted, that if the carbon dissociated out of the fuel should, by striking a cold surface, be chilled below its ignition point, it will be carried away by the waste gases in a solid state (smoke) in which case it is not possible to calculate the combustion from an analysis of the waste gases as the amount of carbon thus lost cannot very well be determined.

General Assumptions

The reactions taking place in the combustion are:

1 lb. C_2 + 2-2/3 lbs. O_2 = 3 2/3 lbs. CO_2
1 lb. C_2 + 1-1/3 lbs. O_2 = 2-1/3 lbs. CO
1 lb. H_2 + 8 lbs. O_2 = 9 lbs. H_2O

If all the participants in the reactions were in a gaseous state the equations of the reactions would read:

1 cu. ft. C_2 + 2 cu. ft. O_2 = 2 cu. ft. CO_2
1 cu. ft. C_2 + 1 cu. ft. O_2 = 2 cu. ft. CO
1 cu. ft. H_2 + ½ cu. ft. O_2 = 1 cu. ft. H_2O

In either case the result would be the same, as the volume of a gas is inversely proportional to the molecular weight so that one lb. of hydrogen will have 16 times as large a volume as oxygen, 14 times as large as nitrogen, 12 times as large as carbon, 32 times as large as sulphur and nine times as large as H_2O. The standard volume of gas is generally calculated at 62 deg. F. Two hundred cbm of hydrogen weigh at 0 deg. C. (32 deg. F.) 9 kg; expressed in cu. ft. and lbs. and corrected to 62 deg. F., the volume of one lb. hydrogen will be

$$\frac{200}{9x2} \times \frac{35.316}{2.2046} \times \frac{522}{492} = 188.843 \text{ cu. ft.}$$

To simplify the calculations I have assumed that 189.0 cu. ft. hydrogen weigh one lb., because using this figure we get simple coefficients.

Volumetrical contents of 1 lb. hydrogen = 189.0 cu. ft.
" " " " " carbon gas = 15.75 "
" " " " " sulphur " = 5.906 "
" " " " " oxygen = 11.813 "
" " " " " nitrogen = 13.5 "
" " " " " H_2O = 21.0 "
" " " " " CO_2 = 8.591 "

That the one value or the other, by weight or by volume, can be interchanged is obvious.

1 lb. C + 2-2/3 lbs. O_2 = 3-2/3 lbs. CO_2
15.75 cu. ft. C_2 + 2-2/3 × 11.813 cu. ft. O_2 = 3-2/3 × 8.591 cu. ft. CO_2
15.75 cu. ft. C_2 + 31.5013 cu. ft. O_2 = 31.5003 cu. ft. CO_2 or very closely
1 cu. ft. C_2 + 2 cu. ft. O_2 = 2 cu. ft. CO_2

Formula.

1. Composition of Fuel.

C_2 — a% (by weight) = 0.1575 × a cu. ft. = al cu. ft. in one lb. fuel
H_2 — b% (by weight) = 1.89 × b cu. ft. = bl cu. ft. in one lb. fuel
S_2 — c% (by weight) = 0.05906 × c cu. ft. = cl cu. ft. in one lb. fuel
O_2 — d% (by weight) = 0.11813 × d cu. ft. = dl cu. ft. in one lb. fuel

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*Assistant Chief Engineer, Illinois Steel Company, Gary, Indiana.

N_2 — e% (by weight) = 0.135 × e cu. ft. =
el cu. ft. in one lb. fuel

100% = Total

2. Composition of Waste Gas (volumetrically by analysis).

CO_2 = f% — fw cu. ft. from one lb. fuel
CO = g% — gw cu. ft. from one lb. fuel
H_2 = h% — hw cu. ft. from one lb. fuel
O_2 = j% — jw cu. ft. from one lb. fuel
N_2 = k% — kw cu. ft. from one lb. fuel

100% —100 w cu. ft. from one lb. fuel

Basing the calculations on the air used for the combustion (the air by volume holding 21 per cent oxygen and 79 per cent nitrogen) we get:

$$kw = \frac{79}{21} jw + e_1 + \frac{79}{21} O$$

when O means the oxygen required for combustion =

$$2a_1 - \frac{aw}{2} + \frac{b_1}{2} - \frac{hw}{2} + 2c_1 - d_1;$$

$$\frac{21}{79} kw = jw + \frac{21}{79} e_1 + (2a_1 + \frac{b_1}{2} + 2c_1 - d_1)$$

$$- w(\frac{g+h}{2})$$

$$\text{Call. } x = \frac{21}{79} k;\ v = \frac{21}{79} e_1;\ y = 2a_1 + \frac{b_1}{2} + 2c_1;$$

$$z = \frac{g+h}{2}$$

$$\text{then } w = \frac{v + y - d_1}{x + z - j} \qquad (1)$$

and total waste gases per lb. liquid W = 100w (2)

$$\text{Air present} \qquad Ap = 100 \frac{(kw - e_1)}{79} \qquad (3)$$

$$\text{Surplus air} \qquad As = \frac{100\, jw}{21} \qquad (4)$$

Air needed for complete combustoin

$$Ac = 100 \frac{(y - d_1)}{21} \qquad (5)$$

Useful air,

$$Au = Ap - As = \frac{100(y - zw - d_1)}{21} \qquad (6)$$

Surplus CO_2 (derived from furnace) =

$$w\ (f + g) - 2a_1 \qquad (7)$$

H_2O and SO_2 in waste gases =

$$v + (b_1 - hw) + 2c_1 \qquad (8)$$

when V = moisture in fuel + steam used for atomization, which is translated from pounds to cubic feet by multiplying with 21.0.

Example.

By-product tar: 2 per cent moisture contents; one gallon weighs 9.75 lbs.

Ultimate analysis—

(Dry) carbon 94.4% = a; a_1 = 94.4 × 0.1575
= 14.868 cu. ft.

Hydrogen 5.6% = b; b_1 = 5.6 × 1.89
= 10.584 cu. ft.

94.4% + 5.6% = 100.0%

Waste gas analysis:

CO_2 — 17.4% — f
CO — 5.2 — g
H_2 — 0.5 — h
O_2 — 0.2 — j
N_2 — 76.7 — k

100.0%

$$W = \frac{v + y - d_1}{x + z - j};\quad v = 0;$$

$$d_1 = 0;\quad y = 2 \text{ x } 14.866 + \frac{10.584}{2} = 35.028$$

$$x = \frac{21}{79} \times 76.7 = 20.3836;\quad z = \frac{5.2 + 0.5}{2}$$

$$= 2.85;\quad j = 0.2$$

$$W = \frac{35.028}{20.3836 + 2.85 - 0.2} = \frac{35.028}{23.0336} = 1.520404$$

Composition of waste gases (non-condensible) from one lb. tar—

CO_2 — 17.4% = 26.4550 cu. ft.
CO — 5.2 = 7.9060 " "
H_2 — 0.5 = 0.7602 " "
O_2 — 0.2 = 0.3041 " "
N_2 — 76.7 = 116.6151 " "

$$\left.\begin{matrix}7.9060 \\ 0.7602\end{matrix}\right\} \frac{7.9060 + 0.7602}{2} = 4.3331 \quad zw$$

100.0% = 125.0404 cu. ft.

$$\text{Air present} = \frac{100 \times 116.6151}{79} = 147.614 \text{ cu. ft.}$$

$$\text{Surplus air} = \frac{100 \times 0.3041}{21} = 1.448 \text{ cu. ft.}$$

Useful air = - - - - 146.166 cu. ft.

$$\text{Useful air} = 100 \frac{(35.028 - 4.3331)}{21} = 146.1662 \text{ cu. ft.}$$

Air for complete combustion =

$$\frac{100 \times 35.028}{21} = 166.800 \text{ cu. ft.}$$

Surplus CO_2 = 26.455 + 7.906 — 2 × 14.868 =
4.625 cu. ft.

We see from these figures that only 88½ per cent of the air necessary for a complete combustion was present and that 99 per cent of this air performed useful work.

On account of the lack of air part of the carbon was only oxidixed to CO; as one cu. ft. carbon gas produces two cu. ft. CO, the amount of carbon gas thus oxidized was 7.906/2 = 3.953 cu. ft. leaving 14.868 — 3.953 = 10.915 cu. ft. carbon gas burst to CO_2 or 73.4% of the carbon. Similarly 92.8% of the hydrogen or 10.584 — 0.7602 = 9.8238 cu. ft. were burnt.

JUDGING THE COMBUSTION OF LIQUID FUELS

Check Up	Cu. Ft. per Lb. Fuel	Oxygen for Combustion	Composition of Waste Gases CO_2	CO	H_2	O_2	N_2	H_2O
C_2	10.9150	21.8300	21.8300	....	....	....	....	....
C_2	3.9530	3.9530	....	7.906	....	....	....	....
H_2	9.8238	4.9119	....	....	....	....	....	9.8238
H_2	0.7602	....	....	....	0.7602	....	....	....
	25.4520	30.6949	21.8300	7.906	0.7602	....	....	9.8238
Nitrogen in air		115.4713	....	....	....	....	115.4713	....
Total air for comb.		146.1662	....	....	....	....	....	....
Surplus air		1.4480	....	....	....	0.3041	1.1439	....
Surplus CO_2		....	4.625	....	....	....	....	....
Total air present		147.6142	26.455	7.906	0.7602	0.3041	116.6152	9.8238

Total Volume of Waste Gas.

Calculations carried on in the above described manner will suffice ordinarily to answer questions pertaining to combustion. Should, however, it be necessary to establish the actual volume of air or waste gas, attention must be given to the moisture present.

Using the same example, this tar, we would say, weighs 9.75 lbs. per gallon and has a moisture content of 2 per cent so that every gallon consists of 9.555 lbs. hydro-carbons and 0.195 lbs, H_2O; to atomize one gallon of tar 4.5 lbs. of steam have been used and the moisture introduced with every gallon of tar and carried away with the waste gases amount to 4.695 × 21 = 98.595 cu. ft. H_2O. The air used for combustion held 6 grains of moisture per cu. ft.; as 9.555 × 147.6142 = 1410.4537 cu. ft. of air were introduced in the furnace with every gallon tar, the addition of moisture from this source is 25.3882 cu. ft. Add the moisture resulting from the combustion or 9.555 × 9.8238 = 93.8664 cu. ft., then the total moisture in the waste gases from one gallon of tar will be 98.595 + 25.3882 + 93.8664 = 217.8496 cu. ft. The other products of combustion from one gallon tar are:

CO_2	— 9.555 ×	26.455	=	252.7775	— 15.13%
CO	— "	7.906	=	75.5418	— 4.52
H_2	— "	0.7602	=	7.2637	— 0.44
O_2	— "	0.3041	=	2.9057	— 0.17
N_2	— "	116.6152	=	1114.2582	— 66.70
		152.0405	=	1452.7469	86.96%
H_2O	- - - -		-	217.8496	— 13.04
				1,670.5965	100.00%

REDUCING THE WASTE IN INDUSTRY

The year has been a notable one because of the great amount of scientific attention which has been given to the problem of eliminating industrial wastes, says the annual report of the director of the Bureau of Standards of the Department of Commerce, covering the fiscal year ended June 30, 1922.

Recognizing for many years that the solution of this problem depends like all fundamental industrial questions upon correct scientific and technical data, the bureau has acted as a clearing house for information. Its staff has assisted in preparing codes and specifications, and it has conducted a great number of important investigations in its laboratories, all with the object of eliminating unnecessary waste in our industries. A few of the investigations are the following:

A complete study of automobile engine performance, both in the laboratory and in cars on the road, is being carried out with the object of increasing the efficiency of internal-combustion engines. If the bureau, through this work, can assist in lowering the gasoline consumption of automobiles only 10 per cent for a given mileage, it will represent a saving to the country of something like $100,000,000 per year.

Large sums are lost each year through the corrosion of underground pipes, conduits, and metal structures. Part of this is the result of electrolytic action while part is caused by conditions of the soil. The bureau has mapped out an extensive program to study this subject, and, if possible, to suggest means for preventing this waste. Pieces of pipe have been buried in different sections of the country, and the effect of the soil in these localities on the metal will be studied.

Most appliances used for heating by gas are operated at very low efficiency, with a consequent waste of gas and also with a very bad effect on persons working in the same room, because imperfect combustion means generation of carbon monoxide, which is extremely poisonous. The bureau has studied the subject of improving both natural and artfical gas burners very thoroughly and has already issued recommendations which will greatly reduce gas consumption and improve the health of the users.

In the field of building construction more material than is necessary is often used for a wall, column, or floor slab, because information concerning the stresses which such structures or members can safely bear, their ability to resist fire, etc., is inaccurate or incomplete. In order to more definitely formulate safe and economical standards in this field, the bureau is investigating the suitability of rerolled steel as a reinforcement for concrete, the strength of walls and floors, the resistance of buildings to fire, and the constitution of cement and concrete.

If, through the above investigations and many others similar to them which might be mentioned, the bureau can assist in preventing even a small portion of the avoidable waste in industry, the saving to the citizens of this country thus brought about would more than pay the cost of many research institutions as large as the Bureau of Standards for a number of years.

Old and New Practices in Heating Pairs and Sheets

To the Editor,
Blast Furnace & Steel Plant,

Sir:—The making of light gauge sheets was, for many years, an industry carried on commercially to furnish material for building purposes and for the manufacture of articles for domestic use.

The art of making these sheets was left to men of long experience who possessed a slight knowledge of a fundamental principle which they guarded zealously. This principle had to do with combustion which unto this day remains a perplexing problem due to changes in the methods of fuel burning which have been introduced without giving this particular heating operation the careful and scientific study it deserves. Although the industry dates back 200 years or more it was not until within the past two decades that it has grown to great economic importance, brought about principally by the demands of automobile manufacture and the use of sheet metal in the manufacture of articles formerly made of castings.

Developments in the metallurgy of steel have progressed to such an extent that the necessary physical and chemical requirements of the steel in the sheet bar are easily met. One difficulty remains, namely, to get such materials successfully rolled into sheets. This operation is attended with more or less discouraging results, a condition that has improved only in so far as it has been possible to become adapted to circumstances

Science in its investigations having apparently sidetracked this branch of industrial heating, the manufacturers receive no help from their metallurgists when they attempt to develop any new material and so they turn it over to practical men who are efficient only when conditions are normal and easy to control. As usual when there is a lack of understanding, difficulties are encountered that result in a chain of effects, the cause of which no one connected with the work reduces to a definite answer. So very few people are competent to judge the character of a flame or the nature of a heat in the steel that an attempt at explanation on the part of one who perchance does know is unfortunately met with but scant consideration because the problems prove to be too obstruse for the average intellect, although the latter may be keen enough in many other things.

Conditions are accepter as a matter of course and ways devised to combat effects rather than to eliminate the cause; and so a state of ignorance is permitted to exist that is not in keeping with modern advancement.

Common sense of the most elementary kind would correct this lack of open-mindedness and remove some of the obstacles that stand in the way of elimination of waste. Those interested should study the main points of the information on this subject which has appeared in the pages of this magazine and which the writer will attempt to summarize.

Llewellen described the method of fuel burning as practiced some years ago. It is not hard to understand from his description that an older generation of men saw the desirability of heating the bottom of the furnace. The manner in which they accomplished this is not sufficiently understood by many engineers, although the method they used in bringing about a proper gasification and combustion of all the combustible constituents of the fuel is quite well known to everyone possessing a knowledge of gas making. The furnace atmosphere, being reducing in character, contains combustible gases and feeds upon the oxygen which finds its way through the door, the operations in the sheet furnace being pretty much of an in and out affair. In view of the fact that the heat is in this manner brought up to the front of the furnace and with the escaping heat passing out through the hollow bottoms and counteracting any absorption from that source, it seems that there is something fundamentally wrong about the claims that have been made as to this method being wasteful. It may be wasteful from a purely thermal standpoint, but it certainly is not wasteful in turning out good sheets.

It is evident that the experiences of men of the past taught them the necessity of having a hot bottom, for in addition to the care taken to have but a minimum of air enter at the rear, coke bottoms were once used, and with the introduction of natural gas hollow brick bottoms were used with gas jets separate from the main supply which entered at the rear and which received the air for combustion through a compact body of hot coke. I mention these facts merely to show that in those days the heaters favored certainty.

Llewellen's description forms a vivid picture of a combustion chamber just hot enough to bring about the necessary chemical reactions and assure continuity of ignition. The hot gases, held in check by the damper, ignite in the heating chamber as they find air, forming what is often spoken of as a hazy atmosphere, that eventually fills the heating chamber, making harmless all excess air by burning it as it enters and compensating for all heat loses from absorption by the brick bottom and the cold steel. This method should be contrasted to the quick combustion now in general use where blower air is used and where the heating is done mostly by radiation. Bright radiation is rather severe on the parts exposed, rendering the surface plastic before the mass is thoroughly heated.

Due to the nature of low carbon steel, the temperature of the heating must of necessity be such that it will offer that resistance to the pressure of rolling which is necessary to insure a close grain and a smooth surface. This calls for a low temperature furnace. With quick combustion practice it is attempted to reach low temperatures by cutting down the fuel supply so that the source of heat becomes more localized with the temperature diminishing according to the distance from the source. On account of the completeness of the combustion, the colder parts of the furnace have no combustible left to neutralize the incoming air and are, in fact, harboring places for gases which the steel will absorb at a red heat, rendering it harsh and brittle, while the oxide of the surface exposed to the rays from above is more or less plastic. On account of the combination of a hard interior with a plastic oxide, the latter adheres to the rolls, producing the different phases or phenomena which were explained by Melaney in the August number of 1922. They are partly due to roll surface conditions, deep scratches from the polishing stones readily lending themselves to picking up steel. Correct polishing of the rolls is an art in itself, an explanation of which is quite beyond the scope of this article, which is intended to deal with heating and combustion entirely.

Low carbon steel, if thoroughly and properly heated in a non-oxidizing atmosphere, retains its natural properties and will not tear out in spots and adhere to the rolls under reasonable pressure or correct rolling practice. This fact cannot be emphasized too strongly.

In summing up the real causes of annoyances and waste of time and material in sheet mill practice, we can lay it to improper heating practice with its imperfect heat distribution, making hot and cold ends in the same bar and hot and cold bars in the same pair, together with the surface condition already mentioned.

Costello has solved this problem with his continuous pair furnace by raising the bars up out of contact with the bottom and surrounding them with gases, such as they may be. The results will be very good, if the gases are reducing or perfectly neutral.

Dishing and spreading of packs during rolling is in most cases due to a wide difference in temperature between the top and the bottom of the pack. For the same reason, most all stickers will be found below the middle of the pack, which simply takes on the same heat conditions that obtain in the furnace.

Trinks, writing in the April number of 1921, calls attention to the fact that sheet furnace bottoms, and especially hollow bottoms, will absorb heat from the steel when operated with so-called perfect combustion which in the case of the sheet furnace means absence of combustible matter in the gases as they sweep by the door and enter into the flues under the hearth. If there were combustible gases in them they would continue to burn in the flues under the hearth and would heat the latter.

We are all aware that both fuel and air are required for combustion, but somehow in our practice we are overlooking the essentials mentioned by Llewellen as to uniformity of temperature, composition of the gases and the place in the furnace where the actual combustion takes place or should take place. Thus we are brought to the realization that the methods used by heaters years ago were, in many respects, superior to so-called "modern and up-to-date" methods.

What does it help a sheet manufacturer to save one-third of the coal required for heating sheets and pairs, if one-half of his output has to be sold for second quality?

(Signed) GEORGE NEWHOUSE.

PULVERIZED COAL TEST ON BOILERS

As pulverized coal firing of boilers is at the present moment being given wide publicity, especially with reference to large power stations use, the following test record in a steel plant will be of interest:

As the operation of boilers in connection with metallurgical plants is never classed with the large power stations used only for public utility and railroad work and the results obtained are usually not expected to compare with the large power plants, we believe that this report will give a good insight into the advantages of powdered coal, even in small boiler plants.

The boiler on which this test was made is at the Ougree plant of the Societe Anonyme Marihaye, Liege, Belgium, and is only one of many other boilers of similar and different types now being equipped for powdered coal firing with the Quigley System.

REPORT OF TEST

This boiler is an Esslingen of the multi-tubular type:

Heating surface	2422 sq. ft.
Lift, hp.	242
Steam pressure gauge	137 lb.
Draft in front of damper	12 in. water
Superheated surface	936 sq. ft.
Date of test	Nov. 7-8, 1922
Duration of test	24 hours
Proximate analysis of Pulverized Coal:	
Fixed Carbon	52%
Volatile Matter	27%
Ash	15½%
Moisture	1%
Fineness through 100 mesh	92½%
Btu. per pound	12744
Feed water temperature	51.8 ° F.
RESULTS	
Evaporation, lb. of water per hour	8927
Evaporation per 10 sq. ft. of heating surface	37.7 lb.
Combustible burned per hour	1146 lb.
Evaporation, lb. of water per lb. of combustible	7.94 lb.
Thermal efficiency	77%
Per cent of rating operated	about 110½
Boiler hp. produced	268.75
Average analysis of flue gas	CO_2—15%
	O — 3%
	CO — 0%
Temperature of gas at outlet of boiler	293 deg. F.
Temperature in combustion chamber	2642 deg. F.
Temperature of superheated steam	473 deg. F.

This test was run in the regular operation of the plant, which accounts for the low percent of rating, and to find out what the equipment of the boiler room would produce, a further trial was run, and it was found possible to operate the boiler at 160% of rating, with no difficulties; but this was the limit of the feed water supply, so there was no opportunity to attempt higher ratings.

WHAT IS A HORSE POWER?

The term "horse power" originated in the eighteenth century, when the mechanical force of expanding steam in engines was replacing the muscular force of horses in hoisting and pumping in the British mines. What number of horses formerly used would the steam engine replace? and how did a horse compare with man? were the questions asked.

James Watt (1736-1819), a Scottish engineer who invented the modern condensing steam engine, was the originator of the term. He first selected a massive dray horse, a dozen normal muscular men, and by means of a rope and traces, beginning with four men, added man after man pulling tug-of-war fashion against the horse, until he found that when eight men were pulling they dead-locked or balanced the horse's strength.

Watt next found by experiment that a horse could lift, by means of block and tackle, 330 pounds at a rate of 100 feet per minute, which, of course, was the same (if gearing were to be used) as lifting 33,000 pounds one foot in a minute, or 550 pounds in one second; accordingly he designed his steam engines and sold them on this basis. One of the highest tributes than can be paid to the memory of James Watt is that the unit of power originating through the magic of his fertile brain, has stood the test of time down to the present day.

The quantity given about, however, must be used with reserve and care as the measure of work which a horse can do in traction or otherwise. The horse can haul for a few seconds greatly in excess of this rate, but, say for eight hours, he will average less. A normal muscular man usually develops about one-tenth of a horse power, but cannot keep it up all day.

WITH THE EQUIPMENT MANUFACTURERS

NEW TYPE MULTI-STAGE CENTRIFUGAL PUMP

The National Power Show, held in New York early in December, presented a wonderful opportunity for close hand survey of interesting new equipment developments.

The DeLaval Steam Turbine Company had on display one of their recently designed multi-stage centrifugal pumps.

Many engineers are not aware of the high efficiencies that can be obtained in centrifugal pumps by the use of a properly designed and proportioned volute rather than by the use of diffusion vanes.

That the highest efficiencies are obtained with volute diffusors is best demonstrated by numerous official tests on volute type centrifugal pumps in water works service. For example, one installed at the Municipal Water Works in Minneapolis has maintained the uniformly high efficiency of 86 per cent over a period of four years, during which time no replacements or repairs whatever have been made to the pump, while another at Toronto showed an efficiency of 87.2 per cent in a recent official acceptance test.

Where pumps driven by motors of slow or moderate speeds must deliver water at pressures higher than are desirable or practicable for a single-stage pump, instead of using a single-suction multi-stage pump, two separate single-stage pumps are sometimes connected in series, so that one discharges into the suction of the other. This method has frequently been adopted, particularly in water works service. In medium and smaller sizes, the use of two independent pumps in series becomes somewhat more cumbersome and a multi-stage pump is more often used. The length of shaft permissible in a multi-stage pump is limited because of the critical speed, and if many stages are employed, the designer no longer has a free hand in providing water passages of the shape and size conducive to the highest efficiency. Consequently, where more than three stages are required, the single suction impeller, which occupies less space on the shaft than does the double suction impeller, and thus permits the use of a shorter shaft, is used.

However, it is not possible to obtain as high efficiencies with a commercial multi-stage single suction pump as would be possible in a single stage pump with double suction impellers, not only because of the less favorable limitations imposed on the impeller, but also because there is not sufficient space for an efficient volute diffusor and suitable return passages leading from the diffusor to the eye of the succeeding impeller. The DeLaval Steam Turbine Company therefore developed a new type of multi-stage pump, known as a "series" pump, in which the advantages of the double suction impeller are retained. This is made possible by the use of a specially formed casing which provides individual volutes for each impeller, with ample interconnecting passages within the casing itself.

The double suction impeller gives perfect hydraulic balance and two of the stuffing boxes which would be required if two separate casings were employed, are eliminated, together with their friction. As compared with a single suction impeller, the double suction impeller has a smaller suction eye, which permits of making the impeller itself smaller in diameter, and hence the pump can be built to operate at a higher speed for a given head and capacity, or for the same speed, head and capacity, a higher efficiency is obtained. Besides giving the highest efficiency, the volute type diffusor is superior to diffusion vanes, in that it is not subject to clogging or rapid wear, and it also gives a broader efficiency curve, that is, a higher average efficiency over a wide range of delivery.

The pump casing is made in two parts, divided on a horizontal plane passing through the center line of the shaft, the suction and discharge openings being in the lower part, so that they are not disturbed when the casing cover is lifted. Perfect form and smoothness in the suction and discharge chambers and the passages connecting the volute of one stage to the suction chamber of the succeeding stage is secured by the use of dry sand molds in casting the casing and cover.

Leakage from the discharge chamber of each impeller back to the suction chamber of the same impeller is prevented by the use of labyrinth wearing rings. One ring of each pair, known as the case protecting ring, is held in a recess formed in the casing and the casing cover. The other ring, known as the impeller protecting ring, is screwed onto the impeller. The intermeshing grooves of the labyrinth rings present a long and tortuous path to water leaking from the discharge to the suction chamber, thus greatly reducing leakage, while at the same time permitting the use of amply large running clearances. One proof of the effectiveness of this device in preventing leakage is the much longer life of such rings as compared with ordinary flat wearing rings.

To prevent leakage from the suction chamber of one impeller to the suction chamber of the succeeding impeller, that is, from stage to stage, the bushings where the shaft passes through the partitions between stages are made of ample length. The shaft is protected between the impellers and from the impellers to the outer ends of the stuffing boxes by bronze sleeves, and the pump case and cover by bushings at the partitions. Sufficient clearance is provided so that the shaft sleeve and the pump casing bushing are not in metallic contact.

The success attained by the series design in improving efficiency is shown by the accompanying chart. The efficiency curve is remarkably flat, that is, a high efficiency is maintained over a wide range of delivery. This is obviously a great advantage, and distinguishes this type of pump from pumps in which diffusion vanes instead of volutes are used for converting the velocity of the water leaving the impeller into pressure head. In other words, the advantage in this respect of the single-stage volute pump is now extended to multi-stage pumps of two and three stages.

SMALL STEAM TURBINE FOR STOKER DRIVE

The London Steam Turbine Company, Troy, N. Y., have been pioneers in the development of a geared turbine unit for stoker drive. Several of them have been in operation in the Cleveland Water Works for a period of over two years, so that in offering this unit to the public the statement is made that all of our development work has not been completed, and we contemplate no experimentation at your expense in your plant. You need have no fear, therefore, that a new or untried piece of apparatus is offered you.

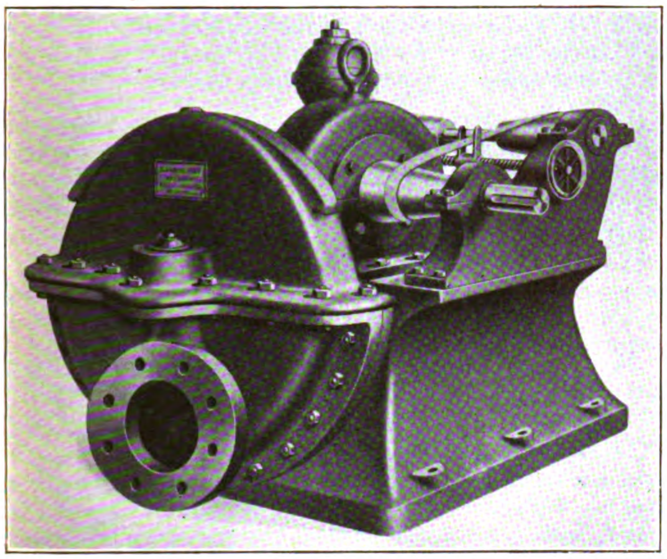
In general, this unit is so simple that it will immediately appeal! It consists of a very substantial gear case containing a pinion and bronze worm gear. To this gear case is attached one of our London steam turbines, this turbine case being bolted to the gear case by means of a heavy flange.

The gear operates in a bath of oil located in the bottom of the gear case, which is water cooled, thus assuring low temperature oil. An oil pump driven from the worm gear shaft supplies oil to the heavy ball bearings shown, thus assuring the bearings of a positive supply of lubricating oil.

The turbine rotor is supported on a steel shaft, on the end of which teeth are cut out to form the pinion, which in turn drives the slow speed worm gear.

This turbine rotor is of the single-stage impulse type, with two rows of blades, in which steam enters through a nozzle of the expanding type on to the first row of moving blades. The steam then passes on to a row of stationary blades which in turn direct it on to the second row of moving blades, when it finally passes out through the exhaust. The turbine casing is horizontally split, thus affording easy access to the interior.

The turbine is provided with a vertical fly ball governor which is both powerful and sensitive. It is driven from the slow speed worm gear shaft by means of belt and conical pulleys which, as can be seen, are readily shifted to alter the speed by adjusting the hand wheel shown. This governor is connected to a balanced inlet valve which controls the admission of steam.



In addition, the turbine is also equipped with a quick acting emergency overspeed governor.

The nature of the work which a stoker drive has to perform, and the location of such a drive, made the London Steam Turbine Company give paramount consideration to reliability and maintenance. It has, therefore, been made very simple within the limits of good engineering practice.

As an illustration, we might cite some of the advantages of this geared turbine stoker drive:

1—The turbine rotor being mounted on the pinion shaft and the turbine casing being bolted to the gear case makes this unit of the two bearing type. It eliminates turbine bearings, thereby reducing maintenance.

2—The turbine shaft and pinion being a single steel forging, a coupling is unnecessary between the turbine and gear. There can, therefore, be no misalignment.

3—The turbine casing is supported at the center line, permitting even expansion of the casing in all directions without disturbing the position of the shaft and its possible misalignment.

4—The turbine is provided with one double labyrinth gland capable of withstanding 35 lbs. back pressure.

5—The turbine has also been so designed that its characteristic curve at all times falls above the horsepower curve of the stoker.

6—It is designed to develop its load at 25 lbs. steam pressure below the specified operating pressure. In addition to this, a hand valve will be fitted with an extra large steam nozzle, so that in starting up the machine when the *main stoker bearings* are not run in ample power will be available until such time as the stoker shaft is properly adjusted. This hand valve can then be closed, and the turbine will then operate under its most efficient condition. In any event, the hand valve will always be available, and can be used in an emergency.

7—Special attention is called to the system of governing. It has been the general custom in connection with stoker work to operate the steam turbine on the throttle, with the result that at low speed the steam is throttled to about 50 lbs. Should an obstruction occur in the stoker the maximum pressure available is 50 lbs. With the system now adopted the governor will throttle the steam down to 50 lbs., or whatever is necessary. but should an obstruction occur the governor valve will immediately open up, thus giving maximum steam pressure at the nozzles. It will naturally remain open until this obstruction is removed, when the governor valve will immediately return to the 50 lbs. necessary for maintaining the required steam. This system is readily shown by reviewing the drawing and cross section, for it will be noted that this speed adjustment is made by turning the hand wheel operating the belt shifter.

8—This drive is arranged for variable speed, with the driven shaft operating between 400 and 100 rpm., and the turbine speed never exceeding 3,600 rpm., thus assuring good economy and the reliability that goes with this moderate speed.

MULTIPORT BACK PRESSURE VALVES ARE NOW MOTOR DRIVEN

The H. S. B. W. Cochrane Corporation of Philadelphia, Pa., are now putting into service a practical remote controlled valve of large size which greatly simplifies a difficult operating problem.

Where exhaust steam is used for heating buildings or for drying or other industrial processes, the back pressure valve is ordinarily located at the top of the building, usually on a vertical exhaust riser. In this location the valve is difficult of access, so that there is a tendency for operating men to carry the same back pressure on the engine at all times, regardless of varying needs for exhaust steam or the back pressure really required. Needless back pressure increases the steam consumption of engines or turbines and may result in a considerable waste of fuel, as can be seen from the accompanying diagram. If the back pressure valve is not only in an inaccessible place, but is also difficult of adjustment, the probability is that unnecessary back pressure will be carried much of the time.

A new form of back pressure valve which has been especially designed for easy regulation is shown herewith. A number of small disks are used, instead of one large disk, and each disk is held to seat by spring pressure, the pressure upon all of the springs being regulated simultaneously by a movable pressure plate, the position of which can be adjusted from outside the valve case. If it is desired to operate the valve from a short distance away, as from the floor above or below, chain and chain wheel or bevel gear and rods can be used.

In order to regulate the back pressure from a greater distance, an improved electric motor control has been devised. The valve can be located on the tenth floor, if necessary, while the remote control panel is placed in the engine room, alongside the back pressure gauge. By simply throwing a switch or pushing a button, the operator sets in motion a motor which drives through a worm gear the pressure plate of the valve, the operator meanwhile watching the pressure gauge and pulling the switch open when the right pressure is reached, or the operator can stop the pressure plate at any desired point. Over-travel of the pressure plate or injury to the motor are prevented by a limit switch attached to the valve casing, as shown in the photograph. The limit switch interrupts the supply of current to the motor, which can, however, be started again by throwing the control switch in the opposite direction.

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The worm wheel is mounted on a sleeve which connects with a hand wheel mounted over a spline on the shaft. The hand wheel shaft is connected to the shaft which drives the valve spindle through a flexible coupling. By loosening a wing nut on the hand wheel, the wheel may then be drawn back from engagement with the worm wheel, and the pressure plate can be lowered or raised manually in case the motor should be out of order or the current supply should be interrupted. The motion of the pressure plate is limited by stops, so that a predetermined back pressure (which is fixed by the strength of the springs used) cannot be exceeded, and since no part connected with the disks extends outside the casing, there is no possibility of jamming by over-tightening of stuffing boxes, or of over-weighting or tying down.

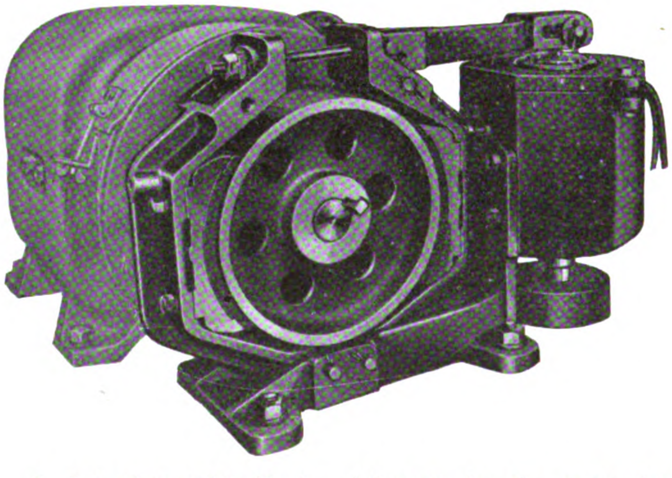
Two types of remote control switches are supplied. The knife switch shown in the photograph will remain in either the closed position or the open position indefinitely. A cylindrical switch is also used which must be held closed in order to keep the motor in operation and which flies back into neutral position as soon as released. In addition to the indicating and recording gauge, which should be placed near to or just above the switch, two pilot lights are used to show when the valve is entirely opened or closed, respectively.

QUICK ACTING BRAKE FOR HEAVY DUTY CRANE SERVICE

The Whiting Corporation, of Harvey, Ill., has solved the problem of a reliable brake for the continuous service imposed by crane operation, in the development of the type "C" Solenoid brake.

The main advantages of this brake are:

1. **Quick Action.** The brake arms are so pivoted that the shoes release equally at all points; there is no chance therefore of the shoes dragging at the lower end as in some designs. This is also a big advantage in applying the brake as the shoes bear equally at all points, resulting in quick braking action and uniform wear.



2. **Interchangeable Parts.** All parts for the same size brakes are interchangeable. Brake wheels and shoes are interchangeable with like parts on standard foot brake.

3. **Easy to Adjust and Change Shoes.** It is necessary to change shoes from time to time on any brake. The shoes are of cast iron, filled with asbestos composition which has been thoroughly tested and proven to be durable and heat resisting to a very marked degree. To take out the shoes it is necessary to remove four cap screws and slide the shoe out. Under ordinary conditions adjustment is only required once a month.

The type "C" brake is of simple design but very rugged and powerful. All parts subject to stress are steel castings. On d.c. brakes, the plunger is of soft iron of large diameter, which gives a fast operating solenoid, even at light loads. The solenoid spool is of brass tubing with vulcanized fiber sleeve over tubing and fiber ends.

The d.c. coils are wound with asbestos-covered wire of ample size. The coil is designed to operate brake at about 40 per cent full load current and remain open at 10 per cent or less full load current. The voltage loss in coil in most sizes averages less than 4 per cent and in no case more than 7 per cent. The a.c. coils are wound with cotton-covered enameled magnet wire of ample size to carry the inrush current when coil is energized. Plunger on a.c. brake is of laminated iron of proper thickness for the service intended.

A 12-in. brake was mounted on a 25-hp., 550-rpm., d.c. motor. In the complete test motor was stopped 50,000 times at a rate of 325 stops per hour, after which the brake showed no signs of wear except the usual shoe wear.

During this test a number of different lining materials were tested and the one selected showed the following characteristics: Material was not affected when operating with the brake wheel at dull-red heat. Average wear .0005 inches per 1000 stops with motor running 1800 rpm.

ELECTRIC DRIVE FOR ROD REELS

H. W. Cope, assistant director of engineering, Westinghause Electric & Manufacturing Company, says in reviewing the achievements of that company:

During the past year an electric drive for rod reels has been put in operation at the Minnesota Steel Company at Duluth. This drive consists of a 100 hp., 115 to 490 rpm., d.c. motor, with a speed maintaining and regulating equipment. In this mill, it is necessary that one of these reels follow the speed of the last stand almost exactly and since the delivery speed of the mill is at times as high as 3,200 feet per minute, any slight error would soon result in a large amount of slack or would pull the rod in two. A small a.c. generator is driven from the main mill motor and another by a 100 hp. reel motor. These two generators operate a mechanical differential which as long as their speeds are the same remains stationary. When the speed of one or the other of the pilot generators changes, the differential rotates and operates the contact of the vibrating type relay which increases or decreases the field on the reel motor, in order that the speeds of the two motors may be brought back together. It has been found possible to hold the speed very accurately with this equipment and there will, no doubt be a large field for it in the future.

A new type of d.c. motor speed regulator has been devised for use in the steel and other industries, where individual motor drive is used, and it is necessary to maintain exact speed ratios between the different machines. For example, where one machine reels material produced on another. This regulator is of the vibrating type, controlled by a mechanical differential. Tests on a 100 hp. motor show that correction for a 100 per cent load change was made in two seconds.

Westinghouse engineers have developed a system of control in connection with the coke pushing machines and ladle cranes where two or more motors are used, only one operating at a given time. For motors of the same capacity, only one set of reversers, accelerating contactors, overload and no-voltage relays and resistors are used. Interlocking is secured within the master controller, eliminating the necessity of contact discs or other auxiliary interlocking contacts on the control panel. Step by step, full automatic acceleration can be furnished.

TRADE PUBLICATIONS

"Feed Water Heaters In Their Relation To Steam Plant Efficiency" is the title of a 60-page booklet distributed by the H. S. B. W. Cochrane Corporation, formerly the Harrison Safety Boiler Works, of Philadelphia. The text matter is not primarily descriptive of apparatus, but rather a presentation of the theory and practice of boiler feed water heating. After showing that the most efficient steam cycle is the one in which the feed water is heated from hot well temperature to boiler temperature by the use of steam withdrawn during expansion, various practical forms of apparatus and their uses are taken up, including vacuum deaerating heaters, back pressure heaters, heaters in conjunction with hot water heating, etc. This pamphlet should be of lively and timely interest to designers, managers and operators of steam plants.

Spur Gear Speed Reducer — The W. A. Jones Foundry & Machine Company, 4401 West Roosevelt Road, Chicago, Ill., now has Catalog No. 26 ready for distribution. You will find embodied in it is technical and practical information complete descriptive matter and illustrations of typical drives. The installation section presents pictorially reducer drives in many large industrial plants. Dimensions, weights and horsepower ratings for complete speed reduction sets are shown.

Patterson-Built Blocks — The W. W. Patterson Company, 54 Water Street, Pittsburgh, Pa., have just issued a new catalog showing their line of Patterson-Built Blocks. The book contains 64 pages, 6 x 9 inches and illustrates their standard wood blocks, oil well blocks and hooks, snatch blocks and weight blocks, as built for either manila rope or wire line. It also shows many special blocks and "C" hooks, Patterson design hooks, wire rope slings, steamboat ratchets and contractors' tools. A number of unusual field views complete the work and make it an interesting, as well as practical and useful catalog of blocks.

The power equipment of the plant of the Marquette Cement & Manufacturing Company, LaSalle, Ill., is described in a leaflet published by the De Laval Steam Turbine Company, of Trenton, N. J. In this plant direct current is used for the operation of cranes, hoists, crushers and other machinery, and is found of particular advantage where variable speeds are required. The current is supplied by a direct current generator of 3750 kw. capacity, driven by a DeLaval compound geared turbine. The latter has two shafts, the pinions of which drive the gear coupled to the generator shaft. This arrangement makes it possible to combine a large number of turbine stages, as required for high efficiency, with the advantages of short, rigid shafts. Cement dust and other impurities, such as water, sludge, and lint are removed from the lubrication system at the Marquette plant by a De Laval centrifugal purifier.

Oil Burners — The F. J. Ryan & Company, Wesley Building, Philadelphia, Pa., have issued their latest bulletin on Oil Burners which contains information upon the very simple way of determining the amount of air necessary for proper combuston and the correct proportions of air with oil.

Thomas Calorimeter—Publication 3010 is a new eight-page booklet just printed by the Cutler-Hammer Manufacturing Company, of Milwaukee, describing the Thomas Calorimeter. This booklet tells about the principal uses of this Recording Calorimeter such as determining and recording the calorific value of water gas, coal gas, blue gas, producer gas, natural gas, and mixtures of these gases. Some of the advantages are enumerated, including the recording of results (continuously and graphically) directly in Btu. per cu. ft. of gas at 30 in. mercury pressure and 60 deg. F. saturated, without any manual operation, computations or corrections. The principle of operation is explained and complete description of parts outlined. Many installation views are shown and a piece of the graphic chart reproduced full size.

TRADE NOTES

The Westinghouse Electric & Manufacturing Company has leased a six story building to be erected on a lot 100 x 150 ft. at Jones avenue and Marietta street, Atlanta, Ga., at a cost of $360,000. The building, which is to be known as the Westinghouse Electric Building, will be constructed according to the company's specifications and will be used as an office, warehouse, and service station. Construction work was started December 1 and will probably be completed by next May.

The Ingersoll Rand Company and the A. S. Cameron Steam Pump Works announce the opening of a branch office at 718 Ellicott Square Building, Buffalo, N. Y. This new office is equipped to render full service to those interested in air, gas and ammonia compressors, vacuum pumps, turbo blowers and compressors, condensers, oil and gas engines, pneumatic tools, rock drills, centrifugal and direct-acting pumps and other of the numerous products manufactured by these companies.

The Pittsburgh Valve Foundry & Construction Company, of Pittsburgh, Pa., has purchased a Moore Rapid 'Lectromelt furnace for its steel plant.

The Blackwood Electric Steel Corporation has purchased a Moore Rapid 'Lectromelt furnace for its new foundry which is under construction at Parkersburg, W. Va.

Bonney-Foyd Steel Foundry Company, Columbus, Ohio, have purchased a 3-ton Moore Rapid 'Lectromelt furnace for their steel foundry. They have a 3-ton Ludlum installed at the present time.

Briggs & Turivas, Inc., Westminster Building, Chicago, Ill., have purchased the iron and steel plant of Frederick Cowin & Company, Inc., Joliet, Ill., formerly the Joliet Rolling Mills; the plant is a complete one, consisting of a combination 8 in. and 12 in. finishing mill, 12-in. and 16-in. finishing mills and a 22-in. muck mill. It has a capacity of 5,000 tons monthly of finished iron and steel and five railroads serve the property. Whether the plant will be sold by Briggs & Turivas, Inc., as a going proposition or dismantled by them is not yet known.

F. J. Ryan & Company, Wesley Building, Philadelphia, Pa., have received contracts for the installation of an automatic gas fired pipe annealing furnace for the National Cast Iron Pipe Company at Birmingham, Ala. This equipment is a duplicate of the two furnaces furnished to the U. S. Cast Iron Pipe & Foundry Company, excepting that the last furnace named was oil fired. They have also received contract from the Graham Nut & Bolt Company of Pittsburgh for an automatic rotating hearth bolt annealing and tempering furnace.

COMING MEETINGS

February 12-17 — The American Ceramic Society will hold its annual meeting in Pittsburgh, Pa.

February 15-16 — The American Society for Steel Treating will hold its winter sectional meeting in the City Club, Chicago.

February 19 — The American Institute of Mining and Metallurgical Engineers will hold its annual meeting in New York City during the week of February 19,1923.

April 3-7 — The American Society will hold its spring meetng at New Haven, Conn.

April 18-20 — The Society of Industrial Engineers, with headquarters in Chicago, will hold its spring convention in Cincinnati. The major subject will be "Management Problems of the Smaller Plants."

May 3-5 — The American Electrochemical Society will hold its spring meeting at the Commodore Hotel, New York City.

NEWS OF THE PLANTS

The Michigan Steel Corporation, 1706 First National Bank Building, Detroit, Mich., recently organized with a paid up capital of $1,000,000, has acquired property in the Lincoln Park section, vicinity of Oakwood, on the Ecorse River, totaling about 35 acres, as a site for the construction of a new steel mill. Plants are well under way for the erection of the initial buildings, to comprise six individual mills, with power house, shops, and other mechanical departments. The plant is estimated to cost in excess of $500,000 with machinery, and will specialize in the production of sheet steel for automobile service, stove manufacture and kindred products. The new company proposes to have the plant ready for occupancy during the spring of 1923. It is headed by Frederick R. Lovejoy, chairman of the board; George R. Fink, formerly connected with the West Penn Steel Company, Pittsburgh, Pa., as president and treasurer; Frank H. Jones, affiliated with the Worthington Pump & Machine Company, vice-president; and W. H .Steele, Detroit, previously connected with the Newton Steel Company, Newton Falls, Ohio, vice-president.

The Blackwood Electric Steel Corporation, Parkersburg, W. Va., recently organized with a capital of $1,500,000, is completing plans and will soon break ground for the construction of a new one-story plant, on local site, 140 x 230 feet, estimated to cost close to $150,000. It is proposed to have the structure ready for service at the earliest possible date. F. S. Blackwood, an official of the Farrel-Cheek Foundry Company, Sandusky, Ohio, will head the new organization, resigning his present connection to devote his entire attention to the new organization. P. T. Thomas is vice-president. Mills, Rhones, Bellman & Nordhoff, 1234 Ohio Building, Toledo, Ohio, are architects.

The Atlas Steel Corporation, Dunkirk, N. Y., is arranging a fund of $250,000, for immediate use in connection with extensions and improvements at its local plant and at its branch works at Charleroi, Pa., to include the installation of new machinery and equipment in a number of departments. Work will be commenced at once on the rebuilding of a section of the Dunkirk works, damaged by fire and causing a temporary suspension in operations in certain departments. L. J. Campbell is chairman of the board.

The Oliver Iron Company, Hibbing, Minn., has plans under way for extensions and improvements in its local plants, estimated to cost about $140,000. The work will include new crushing and screening machinery and auxiliary equipment, to cost approximately $100,000, the remainder of the fund being utilized for new buildings.

The American Steel & Wire Company, 212 South La Salle Street, Chicago, Ill., has arranged an appropriation of approximately $400,000, for extensions and improvements in its works at Anderson, Ind., to include the installation of considerable new machinery, as well as power plant equipment. Harry O'Connor, is superintendent at the local mill.

The American Steel Corporation, Cleveland, Ohio, recently organized under Delaware laws, with capital of $2,500,000, has preliminary plans under way for the construction of a new blast furnace and open-hearth plant in the vicinity of Sandusky, Ohio, to be designed for an annual production of 300,000 tons. The company also proposes to construct a similar plant in Northern Alabama of still larger output. The new company is headed by Henry P. Bope, Pittsburgh, Pa., formerly first vice-president of the Carnegie Steel Company; H. E. McConnell will be vice-president and general manager, formerly in charge of the North Sheron Works of the Carnegie company. Raymond B. Oliver, Scofield Building, Cleveland, will act as general counsel and representative for the company.

The Midland Seamless Tube & Steel Company, Elyria, Ohio, recently organized to take over and operate the local plant of the Cromwell Steel Company, lately disposed of at a receivership's sale for approximately $1,000,000, is perfecting plans for the final organization of the company and the resumption of operations at the local mills. The plant consists of four open-hearth furnaces, bar mill, and other departments for the manufacture of bars for seamless steel tubing, and the new company proposes to continue in this same line. It is said that a number of improvements will be made in the buildings and equipment at the plant, to provide utmost facility in production. It is purposed to give employment to full-time working force. C. A. Orr, formerly vice-president and general manager of the company, and who has been acting as receiver, will be prominent in connection with the permanent organization.

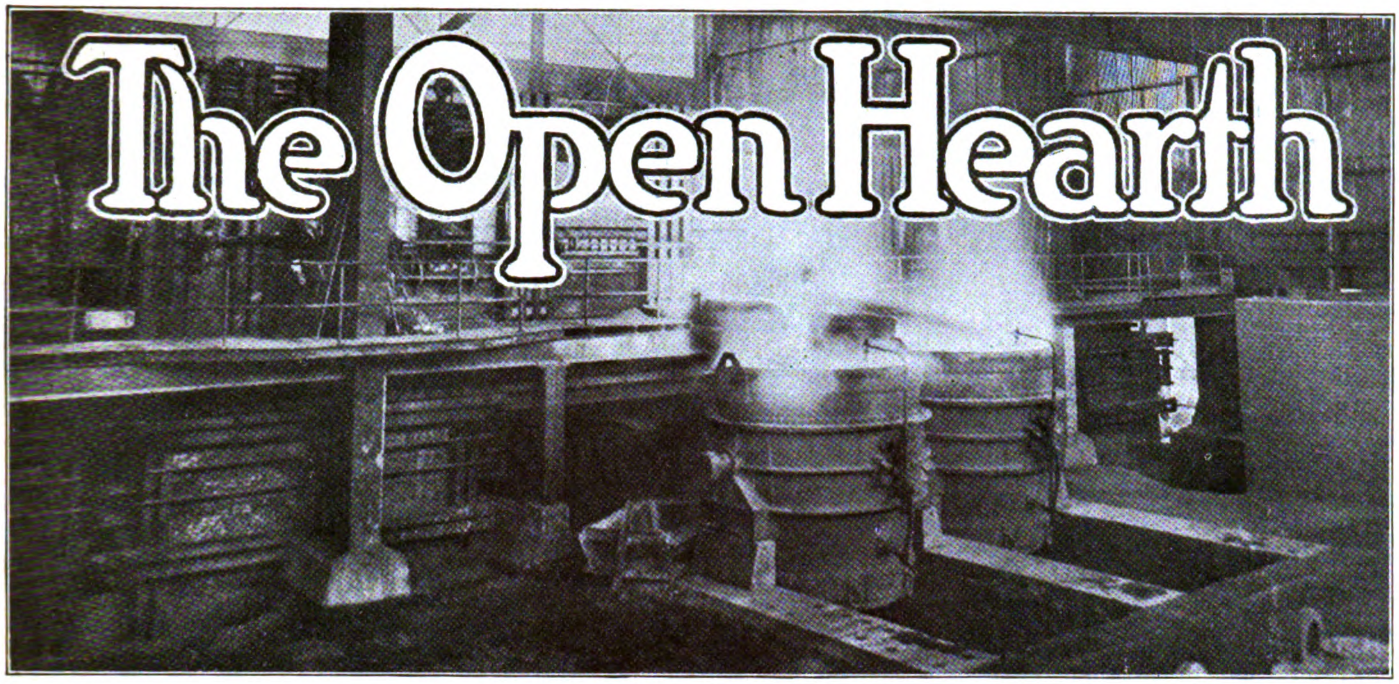
The Gulf States Steel Company, Birmingham, Ala., is perfecting plans for the complete electrification of its bar mill at Gadsden, Ala. Power will be secured from one of the main electric stations of the company, and considerable equipment installed at the mill for the new operation. C. A. Moffett is president.

The Shelby Iron Company, Shelby, Ala., has work under way on relining and repairs at its local blast furnace, and is planning to blow in the stack early in 1923. Incoming orders are being handled from surplus pending the resumption of active production. A working force is being recruited.

The Ford Motor Company, Detroit, Mich., is perfecting plans for the construction of its proposed new steel plant and will place orders for equipment at an early date, including electric steel furnaces, rolling mills, etc. The new plant is estimated to cost in excess of $1,000,000, and will receive its raw materialy from the River Rouge pig iron furnaces of the Ford company. This latter plant is being maintained in active operation, with regular working force.

The Replogle Steel Company, Wharton, N. J., has placed the second furnace in blast at its local mill, and the plant is now on a regular producing basis. The company's mill at the Scrub Oak mine in this same section, has also been placed in service, and it is proposed to resume mining operations in the near future. In connection with the acquisition of an interest in the Wickwire-Spencer Steel Company by J. L. Replogle, head of the company, it is said that there will be a change in operations at the Wharton furnaces, the production being entirely utilized at the Wickwire-Spencer works. Plans are being proposed for general expansion.

The Open Hearth



Col. L. A. May, well known financier and Wall Street operator, of New York, London, England, and Birmingham, Ala., has just returned from a trip to the Orient. He is very optimistic over the outlook for a big trade in Birmingham iron and steel to China and Japan.

* * *

Harry W. Coffin, vice-president and general manager of the Alabama Company, has retired. John W. Porter, vice-president and sales manager has succeeded him. Mr. Coffin held his position with the Alabama Company for the past eight years. He succeeded E. N. Rich, of Baltimore, Md. The Alabama Company is now making a number of repairs and improvements on its second furnace at Gadsden.

* * *

A party of men connected with the steel industry of Australia, visited Birmingham recently. While here they conferred with local steel markets as regards the industrial conditions. They also made a trip to the various steel plants where they inspected these big works. In the party were: John H. McCrum, open hearth superintendent of the Broken Hill Proprietary Company, Ltd., of New Castle, N. S. W.; W. H. Mortlock, of Sydney, N. S. W., and A. G. Douglas of Sydney.

* * *

Fred D. Dimmick, of Philadelphia, Pa., formerly of Birmingham, has been appointed sales manager for the New York territory by the Sloss-Sheffield Steel & Iron Company of Birmingham. This company does a large foundry iron business in the New York territory. Mr. Dimmick succeeds the Devotee-Anderson Company.

* * *

G. A. Sawin, assistant to the manager of the supply department, of the Westinghouse Electric & Manufacturing Company, has been elected chairman of the Committee on Instruments and Measurements of the American Institute of Electrical Engineers. He has been a member of the committee since 1920. Mr. Sawin was born in Cambridge, Mass., in 1878. In 1901 he graduated from Harvard University with the degree of electrical engineer and entered the employ of the General Electric Company. In 1908 he accepted a position as meter engineer with the Public Service Company of Newark, N. J., afterwards becoming service engineer. In 1920 he entered the employ of the Westinghouse Electric & Manufacturing Company in the position which he now holds.

Charles A. Coffin in his 78th year retired on May 16, 1922, from the active leadership of the General Electric Company. Mr. Coffin has been identified with the development of the electrical industry since 1882. He was the founder and creator of the General Electric Company of which he has been the inspiration and leader for 30 years. As an expression of appreciation of Mr. Coffin's great work not only for the General Electric Company but also for the entire electrical industry and with the desire to make this appreciation enduring and constructive as Mr. Coffin's life and work have been, the board of directors of the General Electric Company created on his retirement and now desire to announce "The Charles A. Coffin Foundation."

* * *

Charles A. Coffin Foundation—By action of its board of directors, the General Electric Company has set aside a fund of $400,000 to be known as the "Charles A. Coffin Foundation," the income from which, amounting to approximately $20,000 per year, will be available for encouraging and rewarding service in the electrical field by giving prizes to its employes, recognition to lighting, power and railway companies for improvement in service to the public and fellowships to graduate students and funds for research work at technical schools and colleges.

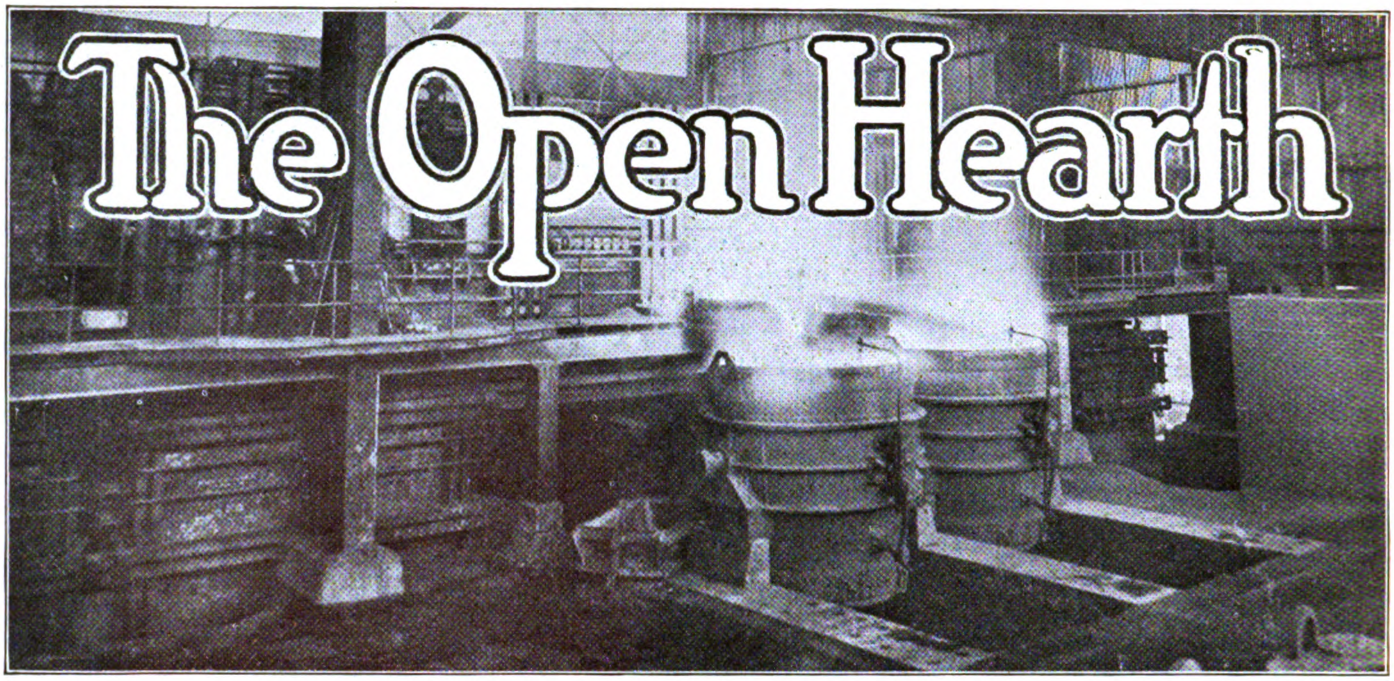
* * *

The foundation will be controlled and administered by a Foundation Committee appointed by the board. This committee, within the limits of the purposes for which the foundation is created, will have power to change the conditions applicable to the distribution of the fund and the amounts for each particular purpose.

* * *

E. C. Brandt, works manager of the Westinghouse-Krantz Works, has been appointed works manager of the new plant now being erected by the Westinghouse Electric & Manufacturing Company in Homewood, Pittsburgh, Pa. Mr. Brandt was born in Tarrs, Pa., in 1887. He received apprenticeship training from 1902 to 1904 with the Kelley & Jones Company, of Greensburg. In 1905 he entered upon the mechanical training course of the Westinghouse Electric Company. Since then he has held a number of important positions, among which are general supervisor of machine tool demonstrators, assistant director of manufacturing operations and supervisor of equipment and methods. He was works manager of the

The Open Hearth



Krantz Manufacturing Company from 1921 until his recent appointment.

V V

H. W. Graham, formerly metallurgist of the Southside Works, Jones & Laughlin Steel Company, Pittsburgh, Pa., was promoted to the office of chief inspector of the Southside Department recently.

V V

W. B Everest, general traffic manager, Westinghouse Electric & Manufacturing Company, died December 5, at his home, 328 Emerson avenue, Pittsburgh, where he had been confined for one week with pneumonia.

V V

W. L. Allen has resigned as vice-president and general manager of Laclede Steel Company, St. Louis, Mo., to become associated after January 1, 1923, with Frank H. Johnson, of Chicago, Ill., in the sale of Laclede Steel Company's and other steel companies' products. Prior to his coming with Laclede Steel Company, Mr. Allen was president of the Valley Steel Company at East St. Louis, Ill., which company was taken over by the Laclede Steel Company in 1918. After leaving college as a metallurgist, Mr. Allen spent several years in the operating departments of blast furnace, open hearth and finishing mill, and was one of the early sales engineers of the armor plate department of Carnegie Steel Company in the promotion of chrome-vanadium and alloy steels. He later acted as commercial engineer of the R. D. Nuttall Company in the development of heat treated gearings. His official connection with the Laclede Steel Company has brought him into intimate contact with the manufacture, sale, and use of hot and cold rolled strip steels.

V V

Fred A. Marsh, general purchasing agent of the Link Belt Company, died at his home. Mr. Marsh was 52 years old and was a member of the Link Belt organization for over 33 years; was one of the organizers of the Purchasing Agents' Association of Chicago, and served ably as its first president; has been for some time a director in the National Association of Purchasing Agents; and will be remembered by his large circle of business acquaintances as a particularly well informed man in his line, of sterling character, absolutely impartial in his treatment o fsellers, buying on merit, and an honor to the important business profession of purchasing agent.

Charles N. Replogle was recently elected president and general manager of the Brightman Manufacturing Company, Columbus, Ohio, succeeding the late W. C. Waggoner.

V V

E. D. Hillman recently became affiliated in the capacity or heating and industrial engineer for the Kings County Lighting Company, 4802 New Utrecht avenue, Brooklyn, N. Y. Mr. Hillman was formerly chief clerk with the Consolidated Steel Corporation.

V V

James H. Stratton, engineer, Wellman, Seaver, Morgan Company, Cleveland, will address a joint meeting of the Associated Technical Societies of Cleveland in a memorial session in honor of Samuel T. Wellman, on the evening of January 9.

V V

E. M. Long, who has been connected with the refining industry for the last 15 years, and who recently joined the sales force of the Calorizing Company, Pittsburgh, has been promoted to district manager of the Southerwestern division, comprising Southern Kansas, Oklahoma, Louisiana, Texas and Mexico. He was formerly connected with the engineering department of the Gulf Refining Company, Port Arthur, Texas.

V V

Ernest G. Jarvis, superintendent of foundries and rolling mills, McNab & Harlin Manufacturing Company, Paterson, N. J., has resigned effective January 1 and expects to take a much needed rest for a few months. About January 15 he will sail for a cruise of South and Central America. After his return he will resume his metallurgical activities in a consulting capacity.

V V

Frank W. Trabold was elected president of the Western Drop Forge Company, Marion, Ohio, at a recent meeting of the board of directors. Mr. Trabold has been in the forging business for several years, principally with J. H. Williams & Company, which he served in various capacities as sales and works manager, general manager and vice-president.

V V

J. M. Hill has been appointed manager of the new sheet mills of the Weirton Steel Company, Weirton, W. Va. Mr. Hill was formerly superintendent of the Canton Sheet Steel Company, Canton, Ohio. He will resume his new duties about January 1.

Some Pointers on By-Product Coke Oven Operations

METHODS OF TRANSFERRING HEAT TO THE COAL MASS IN LOW TEMPERATURE CARBONIZING WITH EXTERNALLY HEATED RETORTS*

Harry A. Curtis, Clinchfield Carbocoal Corporation,
South Clinchfield, Va.

In the carbonizing of coal at relatively low temperatures, the problem of delivering the necessary heat to the distilling coal mass is a difficult one. If we accept the definition of low temperature carbonization which sets the upper limit of temperature at 750 deg. C. (1382 deg. F.), then it is evident that the hottest part of the retort to which either the coal or the distillation products are exposed must be below 750 deg. C. Coal itself is a notoriously poor conductor of heat and it is apparent at once that if the highest temperature at any point in the retort is to be 750 deg. C., then the rate of heat transfer through the coal will be very slow indeed. The proposition of heating the retort internally by passing hot gases or superheated steam through the coal mass has been made a feature of several processes for low temperature carbonization. The scheme has some obvious advantages and numerous disadvantages. We shall not consider this type of heating in the present paper, but limit ourselves to externally heated retorts where the heat must pass through the retort wall before reaching the coal mass.

COKING COAL IN THIN SHEETS AT LOW TEMPERATURE

In an ordinary coke oven, where the retort wall temperature is above 1000 deg. C., the coking reaction progresses very slowly into the coal mass, so that even 10 or 12 hours after the coal has been charged the center of the charge, only nine inches, say, from the hot wall, is still at the temperature of boiling water. With an inner wall temperature of not over 750 deg. C., the maximum for low temperature carbonization, it is readily seen that the coking reaction will progress into the coal mass much more slowly and if this type of oven is to be used at all the width of the oven must be greatly reduced.

The most successful retort of the coke oven type developed so far is that of "Coalite Process" used by the Low Temperature Carbonization, Limited, in their Baraugh Plant, near Barnsley, England.* This oven is 11 inches wide, but there are collapsible iron plates in the center of the oven and the width of the coal sheet is actually only about 3½ inches. The oven wall is of fire brick and is 3 inches thick. The flues run horizontally along the oven walls, the waste gases passing through recuperative systems at ends of the oven. The coking time claimed by the company is eight hours and this appears reasonable. No data are available as to what flue temperature are carried, but it is not likely that they are much below 900 deg. C. The company has at times claimed a large percentage of excess gas for their process, but it is probable that the excess over that required for the ovens is not large. It is the writer's opinion that any claim for excess gas production of more than 25 per cent in a low temperature process is evidence that the carbonization is not truly a low temperature one. A low temperature retort is not an economical gas making device and the ideal amount of gas from a low temperature retort is an amount but slightly in excess of that necessary for heating the retort.

There are several processes for low temperature carbonization, other than the Coalite Process which involve the coking of a stationary sheet of coal. In the Tozier process, for example, the coal is held between the walls of vertical concentric cylinders, while in the Wallace process, now being developed in this country, the coal is held between the walls of a vertical rectangular retort and a steel pipe core.

All such processes, which involve the carbonization of coal in thin layers at low temperatures, suffer from the inherent difficulty of low capacity per retort. In the Coalite process, for example, the capacity of the retort is about 1200 lbs. per charge. On an eight hour coking period, this would amount to 1.8 tons per day. A plant of 1000 tons daily capacity, which is about the minimum for conditions in the United States, would require 612 retorts, allowing for no spares.

There are a number of retorts described in the literature in which the coal is carried through the retort on a moving floor or in containers mounted on cars. We omit discussion of heat transfer in these retorts for the reason that, in our opinion, the only possible salvation for such retorts is an internal heating system

Agitation of Coal Mass as a Means of Increasing Retort Capacity.

Stirring the coking coal mass greatly increases the rate of coking by bringing fresh material continually to the hot retort walls. To be sure, the heat must still be transferred from the retort wall into the adajacent coal, but the mechanical action of stirring carries the heated coal from the retort wall to other parts of the coal mass. In other words, there is a rapid mechanical transfer of the absorbed heat into the coal mass instead of a very slow flow of heat through the poorly conducting layer of coal. Added to this effect is also that which results from the possibility of carrying a greater temperature gradient between the retort wall and the coal mass, for the fresh material carried up to the retort wall by the stirring is at a lower temperature than the material which has remained for a time in contact with the hot wall. The stirring of the coal during carbonization has marked advantages, aside from the matter of improving the heat transfer. For example, it gives an even distribution of the volatile matter remaining in the coke as it is discharged, whereas if the coking is done in a stationary coal layer, the coke next the retort wall is "overdone" by the time the reaction has progressed to the coal mass farthest away from the retort wall.

The two most serious drawbacks to stirring the coal during carbonization are, first, the tendency of the coal to coke on the moving parts, such as paddles and paddle shafts, and eventually plug the retort, and, second, the layer of carbon which forms next to the retort wall gradually hardens, filling up the clearance between the retort wall and the paddles or other stirring device, until eventually this hard carbon deposit interferes with the movement of the stirring device. In the Carbocoal Process, the plugging of the retorts has been completely eliminated by using two parallel paddle shafts running lengthwise through the retort, with paddles so arranged that the paddles on opposite shafts mutually clean each other as they pass. The trouble from carbon deposit on the retort wall has been partially solved, so that a retort can be run at least three months without stopping. Sooner or later, however, the carbon deposit must be removed.

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*Paper presented before the American Gas Association Convention.

*For a brief description of the Barugh Plant see "Engineering" Vol. 112, page 59 (Oct. 28, 1921).

This carbon layer on the inside of the retort naturally interferes with the transfer of heat to the coking coal. In the retorts used in the Carbocoal Process at Clinchfield, however, the actual effect of this carbon deposit on the capacity of the retort is surprisingly small, indicating that there are other factors which are of greater weight in fixing the carbonizing capacity of the retorts. The retorts used at Clinchfield easily handle 100 lb. per hour per retort and can be pushed to 1800 lb. per hour without seriously exceeding the temperature limit mentioned.

In speaking of a maximum shell temperature of 750 deg. C., attention is called to the fact that in most of the published accounts of experiments in low temperature carbonization, the temperatures are taken in the free gas space of the retort and not at the retort shell where the coking is most rapid. We have found that a shell temperature of 750 deg. C. will give a gas space temperature ranging from 350 deg. C. at the feed end to 550 deg. C. at the discharge end of the retort under normal operating conditions. These relationships will, of course, be different for every type of retort.

Means of Securing Large Area of Contact Between Heating Surface and Coal Mass

It is, of course, obvious that the largest possible area of contact between the retort wall and the coal should be secured. This is one of the underlying ideas in the various types of revolving cylinder retorts which have been proposed. In such a retort the whole lateral area of the retort becomes the heating surface. The well-known Thyssen retort, used extensively on the brown coals of Germany, is a good example of such a retort. The usual plan is to mount the revolving cylinder in a furnace and apply heat along the bottom and sides. The old Thomas retort, however, involved the novel idea of building the flues in the shell of the retort itself.

It is very doubtful if any of the simple revolving cylinder retorts which have been patented will operate with a coking coal, due to the fact that the coking coal will stick to the retort walls and eventually plug the retort. It may prove feasible to operate some sort of a mechanical device for breaking down the coke and several such devices have been patented, but there are many difficulties involved and it is almost certain that most of the devices suggested will not operate.

Several retorts have been patented in which it is hoped that both agitation of the coal and increased heating surface are secured by using hollow screws or stirring arms through which hot gases are passed. The ends sought are desirable, but in practically all of these retorts inadequate provision or no provision is made for breaking out the coke which collects on the moving elements when a fusing coal is carbonized.

Materials Available for Retort Walls.

Other things being equal, the best possible heat conductor is ideal material for a retort wall. Of course, other things are never equal. The heat conductivity of a metal is so superior to that of a refractory material, that many retorts of iron or steel have been designed. Not one of these has as yet reached definite commercial success, but it is not unlikely that a metal retort will eventually be used for low temperature carbonization. At present, however, the low temperature processes which are furthest along toward commercial success are using retorts of refractory materials, such as fire brick or silica. The Carbocoal Process as carried out at Clinchfield uses retorts built up of carborundum shapes. This material is very strong, permitting a relatively thin retort wall, and has about six times the conductivity of firebrick. In the most recent type of retort for the Carbocoal Process, such as the one designed by Mr. C. V. McIntyre and tested by the writer at Irvington, N. J., only the lower half of the retort is built of carborundum, a cast iron cover forming the top of the retort. This gives not only a cheaper retort, but a much more convenient one to clean.

The chief disadvantage of carborundum is its cost. It oxidizes very slowly in use, but the shapes are easily replaced in the retort when they get too soft for use. An oxide refractory of higher heat conductivity than silica, would be, however, a welcome invention in the art of low temperature carbonization.

In none of the foregoing pages have we given consideration to the actual arrangement of burners, flues, recuperators or regenerators used in the various retorts which have been designed for low temperature carbonization. To do this would convert the present brief report into a bulky treatise. In passing we remark that the well known principles of furnace design apply, and freak designs are to be regarded with suspicion.

ACCIDENTS AT BEEHIVE OVENS

The beehive coking industry in 1921 reached a lower level of activity than at any time during the period for which accident reports have been received by the Bureau of Mines. At the 17,509 ovens in operation only 6,011 men were employed during the year, more than 4,000 below the number employed in the preceding year. Averaging 141 working days per man, the total working time was equivalent to 850,543 shifts for all employees, as compared with 276 days and 3,028,062 shifts in 1920. Five fatalities and 336 nonfatal injuries during the year resulted in accident rates of 1.76 killed and 118.52 injured per thousand full-time or 300-day workers. For 1920 the corresponding rates were 1.09 killed and 102.54 injured. Pennsylvania, the largest producer of beehive coke, employed 4,208 men, who averaged 124 work days and whose accident rates were 2.88 killed and 162.16 injured per thousand full-time workers. It should be stated that the apparently higher rates at Pennsylvania ovens may be due, in part, to the keeping of more complete records of accidents, particularly minor accidents, than are kept in some of the other states.

Most of the injuries at beehive ovens during the past year were chargeable to haulage, hand tools, falling objects, burns, and falls of persons. Of the five fatalities two were caused by falls of persons, two by coke-drawing machines, and one by haulage.

The production of beehive coke in 1921 has been estimated by the United States Geological Survey at 5,561,000 net tons as compared with 20,511,000 tons in 1920. The 1921 production was smaller than for any year since 1885. On the basis of production the fatal and nonfatal accident rate was 61.3 per million tons in 1921 as against 51.0 in 1920, 72.2 in 1919, and 71.3 in 1918.

"Comparative Tests of Steels at High Temperatures," by R. S. MacPherran, chief chemist, Allis-Chalmers Mfg. Company, Milwaukee, and "Annealing Gray Cast Iron," by J. F. Harper and R. S. McPherran, make up Bulletin No. 241 of the Allis-Chalmers Company. The tests were made in the company's laboratories in a study of the properties of various materials under special conditions. The results of the investigations have been presented before several technical societies.

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The Blast Furnace and Steel Plant

Pittsburgh, January, 1923.

Lowering The Cost Per Ton

During the past year Hyatt roller bearings have been applied to additional mill tables, wire blocks, cars, buggies, etc., in twenty-one plants as follows.

Mill Tables	
Allegheny Steel, Brackenridge	main reversing tables—34″ blooming mill
Carnegie Steel, Mingo Junction	main reversing tables—32″ blooming mill
National Enameling & Stamping, Granite City	main tilting tables—90″ plate mill
Tennessee Coal Iron & Railroad, Fairfield	all tables—11″ merchant bar mill
Ingot Mould and Charging Box Cars	
American Steel & Wire, Newburgh	45 charging cars
Bethlehem Steel, Sparrows Point	115 charging cars
Brier Hill Steel, Youngstown	18 ingot cars
Carnegie Steel, Youngstown	75 charging cars
Follansbee Bros., Toronto	37 charging cars
Illinois Steel, Gary	5 ingot cars
Illinois Steel, South Chicago	10 ingot cars
Interstate Iron & Steel, South Chicago	27 charging cars
Mansfield Sheet & Tinplate, Mansfield	12 charging cars
United Alloy Steel, Canton	27 ingot cars—30 charging cars
Wisconsin Steel, South Chicago	75 charging cars—85 ingot cars
Youngstown Sheet & Tube, Youngstown	290 ingot cars
Wire Mill Equipment	
American Steel & Wire, Cuyahoga	100 wire buggies
American Steel & Wire, Worcester	75 wire buggies
Minnesota Steel, Duluth	150 wire buggies
Pittsburgh Steel, Monessen	60 wire buggies
Whitaker-Glessner, Portsmouth	72-22″ wire blocks—500 wire buggies—300 line shaft bearings

There are now over 4300 Hyatt equipped charging and ingot cars in 38 plants and 38 Hyatt bearing mill tables in 26 plants in this country and abroad.

Every one of these Hyatt steel mill roller bearings is making a worthwhile reduction in the production cost of steel.

Is your plant taking full advantage of the operating economies afforded by the use of Hyatt bearings? Ask our engineers for complete data.

Hyatt Roller Bearing Company
Chicago—Philadelphia—Pittsburgh

Note— See interesting data on page 53 of this issue.